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THE KOERTING 200-HORSE-POWER VALVELESS TWO-CYCLE PETROLEUM ENGINE FOR SUBMARINE BOATS.

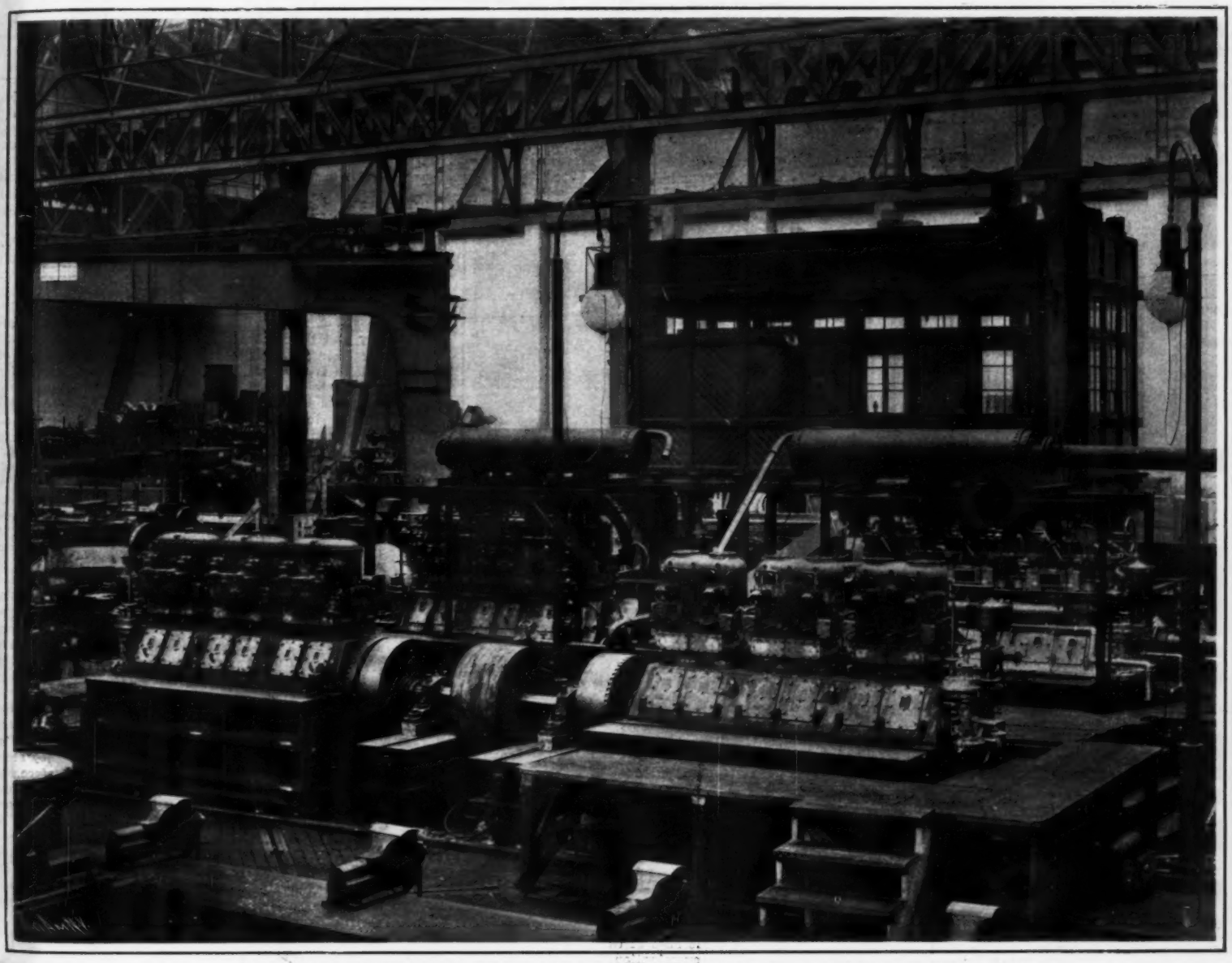
By the English Correspondent of SCIENTIFIC AMERICAN.

AN interesting internal-combustion motor for operation with the ordinary grades of petroleum fuel has recently been designed and perfected by the eminent firm of gas engine manufacturers, Messrs. Koerting Brothers. This motor, which acts upon the two-cycle principle, possesses many novel and striking features, and has been especially designed for the propulsion of submarine boats, upon which the existing four-cycle types, burning the more volatile fuel gasoline, are at present attended with a certain element of danger, owing to the inflammability and explosive nature of the gaseous mixture employed. In the new Koerting engine, valves and their attendant gear are entirely dispensed with, thereby avoiding the intricate and troublesome mechanism inseparable from the ordinary Otto type of motor, the control of the inlet and exhaust being regulated exclusively by the position of the piston. The only movable mechanism retained in addition to the driving gear is the half-time shaft for the ignition.

In the general type of two-cycle engines the exhaust gases are discharged from the combustion chamber simultaneously with the admission of the succeeding charge of gaseous vapor into the cylinder, whereas in the Koerting engine fresh air is admitted into the cylinder while the consumed gases of the charge are being exhausted, thereby providing as it were a layer or charge of fresh air between the hot exhaust gases and the fresh charge of explosive gas. The principle upon which this result is attained may be gathered from the accompanying diagrammatic sectional illustrations of the engine cylinder during the cycle of operations of the piston.

In the first position the piston is shown on the point of commencing its upward stroke. In the crank chamber there is a pump compartment, and in this compartment at this juncture a vacuum is created, while the explosive charge within the combustion chamber is compressed. When the vacuum reaches its maximum the charge of vaporized petroleum and air enters the cylinder at *D* (position II.). With the inlet port *B* is connected an air slot *C* (position III.) of the overflow channel *F* through a shell-shaped aperture *E* in the piston, so that fresh air is drawn into the channel *F* through *C*, *E*, and *B* by the vacuum created in the crank chamber. As the piston rises, a mixture of air and gas is drawn in through *D* and fresh air through *C* into the channel and the crank chamber, while simultaneously the mixture above the piston in the cylinder is further compressed and fired in the usual manner when the piston is at the dead center. On the return or downward stroke the air admission port *C* and the admission channel *D* (position IV.) are closed, thereby interrupting the communication with the crank chamber. During the upward stroke the fresh explosive mixture for the next charge was drawn into the crank chamber, and this charge is compressed during the downward stroke of the piston. When the latter has almost reached the limit of its downward stroke the exhaust slot *A* (position V.) is opened, and almost immediately afterward the inlet port *B* is opened (position VI.) and the pure air that was drawn into the channel *F* through *C*, *E*, and *B* during the upward stroke is now swept into the cylinder, and is instantly followed by a fresh charge of gas from the crank chamber. Thus it will be seen that immediately after each exhaust of the spent hot gas a volume of fresh cool air is admitted into the combustion chamber, thereby assisting in the complete exhaustion of the fired charge. The piston continues its descent until its lowest dead point is reached, while the explosive charge for the next explosion is entering the cylinder, and the same cycle of operations is then repeated.

The system is both simple and highly efficient, as extended trials of several hours' duration under full-load conditions have conclusively demonstrated. The engine shown in the accompanying illustration is a six-cylindered motor developing 200 horse-power at a nominal running speed of 500 revolutions per minute, though capable of acceleration to a maximum of 650 revolutions per minute. It will thus be observed that the engine is of the slow-running type. The engines are constructed in three units each, consisting of two cylinders bolted to a common bedplate. The cylinders are water-cooled, and have a communicating vapo-



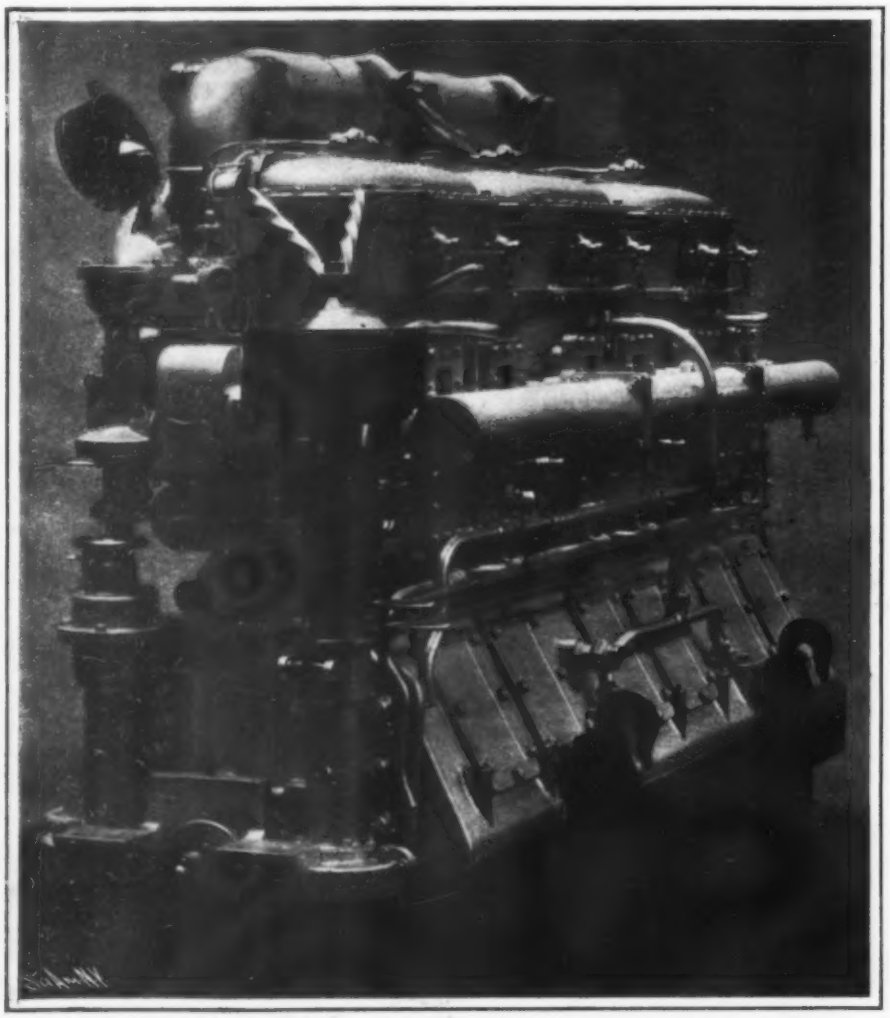
IN THE ENGINE TESTING SHOP, SHOWING FOUR SIX-CYLINDER SUBMARINE ENGINES UNDER TRIAL.

THE KOERTING 200-HORSE-POWER VALVELESS TWO-CYCLE PETROLEUM ENGINE FOR SUBMARINE BOATS.

rizer. All the engines exhaust into a common pipe leading to a single silencer.

The crank case is constructed of phosphor bronze, and carries the bearings for the chromium-nickel-steel crank shaft. The cylinder heads are bolted down to the upper half of the crank case, which is divided longitudinally into two sections, and fitted with doors for facilitating access to the interior of the crank case for the inspection of the crank shaft and the internal bearings, the removable inspection doors being furthermore fitted with celluloid windows.

The crank shaft bearings and connecting rods are lubricated upon the splash system, the used oil collecting in the bottom of the crank case, from which it is drawn off into an oil cooler and then carried to a filter, whence it is drawn by a lubricating pump, and thrown on to the various parts to be lubricated. For the pistons special lubricating pumps are fitted. The pistons are made of cast steel, and the connecting rods of Siemens-Martin steel. All the bearings are of bronze, lined with white metal. The vaporizers are made of phosphor bronze, and are heated by the gases from the exhaust. The admission to the vaporizers of the petroleum is controlled by needle valves. The ignition is carried out upon the usual make-and-break system, with low-tension magneto, the half-time shaft being carried horizontally alongside the cylinders, with the usual device for retarding and accelerating the spark.



THE SIX-CYLINDER 200-HORSE-POWER VALVELESS TWO-CYCLE KOERTING ENGINE FOR SUBMARINE BOATS.

The speed of the engine is controlled by throttling, a special sensitive governor being fitted.

The petroleum fuel is supplied from main storage tanks, the feed to the vaporizer being effected by a small centrifugal pump. A novel feature of the engine is the system of warming the cylinders and vaporizer before starting the motor when cold. This is effected electrically, the engines for some time being driven by a small electric motor, and volumes of electrically heated air being swept through the vaporizers and cylinders. When the walls of the cylinders and the vaporizers have thus been warmed, the engine can be started easily with the petroleum fuel. From the trials that have been carried out, it has been found that the engines can thus be set in motion under their own fuel after five minutes' treatment with the electrically-heated air.

TESTING RUBBER SAMPLES.

IN a recent number of the Gummi Zeitung, Dr. Ditmar describes a method of testing the comparative liability of rubber samples to sun cracking. It is not practicable to expose the samples to sunlight for any length of time, as in the first place it is inconvenient to wait so long for the results of the tests, in addition to which they are at the mercy of the weather. Weber has described a method by which the action of air and sunlight can be imitated in the laboratory. He exposed weighed pieces of rubber of equal area to the action of a solution of acetone peroxide for a period of two days. The increase in weight represents the liability to sun cracking. He states that he found the results obtained by this method to agree well with the effects produced by exposure to sunlight. I cannot remember having come across detailed figures or results described in full. Two days' action has not much visible effect on the surface of samples which I tried, but if the action be prolonged, the rubber presents a blistered appearance. Ditmar replaces acetone peroxide by gaseous oxygen under pressure, at the same time the sample is heated to 100 deg. C.

His procedure is as follows: About half a gramme of the rubber under examination is placed in a strong glass tube sealed at one end, the other being drawn out a little. A current of oxygen is then led into the tube through a narrower one, and when the air is completely displaced, the tube is sealed up. It is then heated for five to twenty hours in a tube (Cavius) furnace at 100 deg. C., and after cooling, is opened, and the rubber taken out and weighed. The increase in weight due to absorption of oxygen is a measure of the liability of the rubber to sun cracking. Of course, the test is only comparative. In some cases, curiously enough, there is a considerable decrease instead of an increase in weight, possibly due to the oxidation of the sulphur to dioxide, which being a gaseous substance, is lost. In such cases Ditmar regards the loss in weight as a measure of the permanence of the rubber article under examination, but it is difficult to understand how such a consideration can be applied in practice. How would he compare two rubbers, one of which gained a little and the other lost a little during the oxygen treatment? Some samples that were examined lost as much as 37 degrees by weight, and it is difficult to see how this is to be accounted for on the above explanation. It is only the uncombined sulphur which is oxidized, and hence the conclusion must be drawn that the samples in question contained at least this proportion of sulphur.

On the other hand, some samples showed as great an increase in weight, which is also an astonishing result. The absorption is influenced by the porosity, which has probably little to do with the permanency of the sample—an evident drawback to the process.

Dr. Ditmar recommends the use of tests for tensile strength, in conjunction with his oxidation process. The tensile strength is measured before and after oxidation, and conclusions may be drawn as to the deterioration of the sample when exposed to oxidizing influences. Eventually, Ditmar has somewhat modified the mode of carrying out his oxidation test, with a view to rendering it more applicable in general practice. The glass tube is replaced by a strong U tube, fitted with glass stop-cocks. A current of dry oxygen is passed through until the air is swept out, when the farther cock is closed, so that the rubber is exposed to the pressure of the oxygen gas in the gasometer. The U tube is immersed in boiling water, and in this way the rubber is exposed to the necessary temperature under a small, although constant pressure. The modification he has found to answer well. In all probability the conditions of the experiments are more constant when working in this manner, as the pressure will not vary with the amount of oxygen absorbed.

PRACTICAL RESULTS IN THE PREPARATION OF PLASTIC MATERIAL.

IN earlier times, when the demand for cheap plastic articles for use and ornament was much smaller than it is now, this branch of industry only attained very modest proportions; in fact, with the exception of gypsum articles, objects made from plastic material were scarcely ever met with. For the problem is, partly to utilize the waste products from certain substances, such as bone, ivory, horn, wood, meerschaum, etc., partly to imitate these substances (some of them were exceedingly valuable) and in this way to make a production on a large scale possible, but mainly to supply certain objects of perfect make and at the same time at a cheap price, and this was impossible with the suitable materials then known.

Many otherwise worthless substances may be made use of in the preparation of these plastic masses; many thousands of active workers find employment, and this branch of industry may justify its existence on these grounds alone, and even from an artistic point of view it is not so objectionable as it is sometimes represented to be. If we aim at the highest perfection of form, if we endeavor to provide the public only with what is really worthy and in good artistic taste, it will be seen that the material of which the objects are made is of quite secondary importance.

The first artificial material used for these objects was plaster of Paris or gypsum; then it was attempted to add other substances to the gypsum, partly to make it harder and partly to retard the hardening process, which was frequently too rapid. Efforts were also made to overcome its brittleness by mixing it with fibrous matter, linen and cotton thread, paper, etc. Often it was attempted to harden the plaster castings after completion with various chemicals, e. g., water-glass, but the results have not always been satisfactory and the hardening of gypsum must be regarded as still in its experimental stage. The manufacture of articles from gypsum is the simplest imaginable, for nothing is required except vessels in which to prepare the gypsum mass and molds in which to pour it and allow it to harden. The molds are sometimes made of gypsum, in which case, on account of the rigidity of this substance, they are made in separate parts which must be joined or tied together when required for casting; sometimes elastic glue-molds are used in which deeply undercut objects can easily be made as the molds are flexible and can readily be removed from the hardened gypsum articles. The most obvious and natural binding agents for articles made from plastic material were glue and substances such as resins, etc. These were mixed with the pulverized matter till the whole formed a tough, thick paste, which was pressed into suitable molds made of gypsum, wood, or metal, nothing but manual labor being used in these operations, then taken out, dried in the open air, and finally provided with a suitable coloring to hide the natural unpleasant and indifferent color.

The drying of these masses is attended with some difficulty, which is greater or less according as the binding agent contains more or less water. All masses in the preparation of which water enters contain a considerable amount of moisture even when they seem very compact; they dry thoroughly on the surface but remain soft inside and are liable to crack when exposed to further drying in the open air. This is more especially the case with masses containing starch or paste. Paste holds a considerable quantity of water and objects made of material containing this binding agent are really incapable of being dried at an ordinary temperature. The drying process must be performed in specially constructed drying chambers heated to a fixed temperature and provided with good ventilation to draw away the damp vapors, and even then great care must be taken to avoid cracks. Kettles for boiling the binding agent, molds of various material and finally the drying chamber are necessary in the preparation of these masses.

Other masses again, such as those containing rosin, can only be prepared by applying heat and must be poured or pressed while hot into the molds. Difficulties are moreover liable to arise in connection with the blending of the constituents, also with the molds and their removal from the finished articles. Boilers for melting the rosin, contrivances for mixing, casting-spoons, etc., are required for making these articles unless the rosin is mixed in the form of powder with the other substances and pressed into the molds at a fixed temperature, in which case the various admixtures combine with the melting or at any rate softening rosin.

In the preparation of papier mâché articles the important question is whether the pulp is obtained ready from the paper factory, or whether the operator has to prepare the paper waste himself. In the first case the pulp is simply mixed with the binding agent and put into suitable molds; in the second case a kettle for boiling, and proper appliances for tearing up the paper stuff will be required. The papier mâché masses are first pressed into proper molds by means of simple presses, left to dry in heated rooms and varnished or

decorated as required. The main point in the varnishing process is to see that the varnish is absorbed by the pulp and spreads uniformly through it; then when it is dried in the oven it will harden and the pulp will become compact and almost unbreakable.

Other masses again, such as compounds of cement and zinc-chloride, require no special drying process. They are poured when in a more or less pasty condition into glue molds or into iron or wooden molding boxes and harden in consequence of a chemical process during which very little free water appears.

The methods of preparing the various masses or objects which have been briefly alluded to are as a rule very simple and can be carried out with little cost; they are not, however, applicable in all cases and under all circumstances, and there has been a tendency of late to manufacture such objects by a process which must be characterized as complicated and somewhat costly.

Owing to the long and very troublesome method of drying in drying chambers and the impossibility of always avoiding cracks, the plan has been adopted of putting the mass into the mold, not as hitherto in the form of paste, but in the form of moist powder. But to obtain a solid article from powder, a very powerful pressure is necessary, such as it is impossible to impart with the hand or with presses worked by hand. Moreover it is necessary to be able to heat the molds at the moment when the pressure is applied, and for this special heating contrivances, most of them involving the use of gas, are required, as with masses made from blood, albumen, amber, casein, etc.

Plastic masses are now made of all manner of material, such as paper, wood, gypsum, meerschaum waste, metal, leather, cotton thread, peat, infusorial earth, etc.; in fact there is no material, especially when it can be procured cheap in the form of paste, which cannot be made into solid bodies of any required shape with the aid of some binding agent and by applying more or less pressure.

In the preparation of all masses it is specially important to use the dry materials in the form of very fine powder and not to use more of the binding substance than is necessary for binding the dry matter. An excess of this binding agent hinders the hardening and is squeezed out when the objects are molded under pressure, and this is apt to be injurious to the strength and hardness of these objects.

SOLDERS.—I.

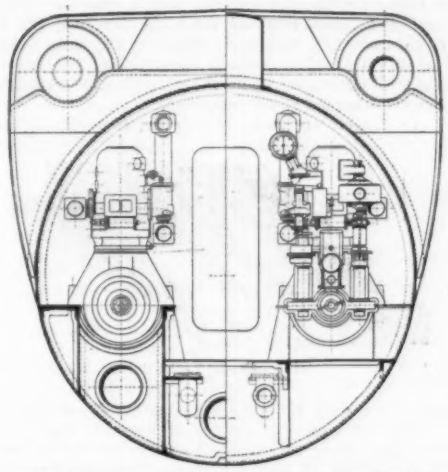
THE metals, or metallic mixtures, which are employed for the purpose of joining other metals, with the aid of heat, are known by the general name of solders. Their number is considerable, as soldering is done not only with pure metals, but also, and more frequently, indeed, with various alloys.

Solders are classified according to the manner in which they are used, with further distinctions in regard to their fusibility and to the metals which are to be soldered. We will take up first the most general classification, referring later to special cases.

The two principal classes may be distinguished as homogeneous and heterogeneous solders. The first consist of the same metals as those which are to be joined to each other; the latter either of a foreign metal or, more frequently, of a mixture of metals.

The homogeneous solders are, of course, the simplest, and in general most to be recommended, since it is possible, with them, to make the soldered article appear as if actually cast in one piece. But they are less frequently employed now than formerly, when fewer good solders were known; and this for the reason that this method of soldering is somewhat difficult, and requires in most cases a very high temperature. It has recently been revived, however, for many purposes, since devices have been learned for obtaining a very high degree of heat in a short time.

The heterogeneous solders, consisting of alloys, have the advantage that by proper changes in their composition they can be easily adapted to any special purpose,



TWO-CYCLE SIX-CYLINDER KOERTING ENGINE USED IN SUBMARINE BOATS.

and thus the labor is lightened. Since the so-called soldering machine has been so far perfected that a good deal of soldering can be done without the use of a soldering iron, simply by letting the melted solder run into the seams, many kinds of solder, even quite hard, are used in this way, and the work of soldering is thereby considerably simplified.

CLASSIFICATION OF SOLDERS.

Solders are divided, according to their fusibility and special uses, as follows:

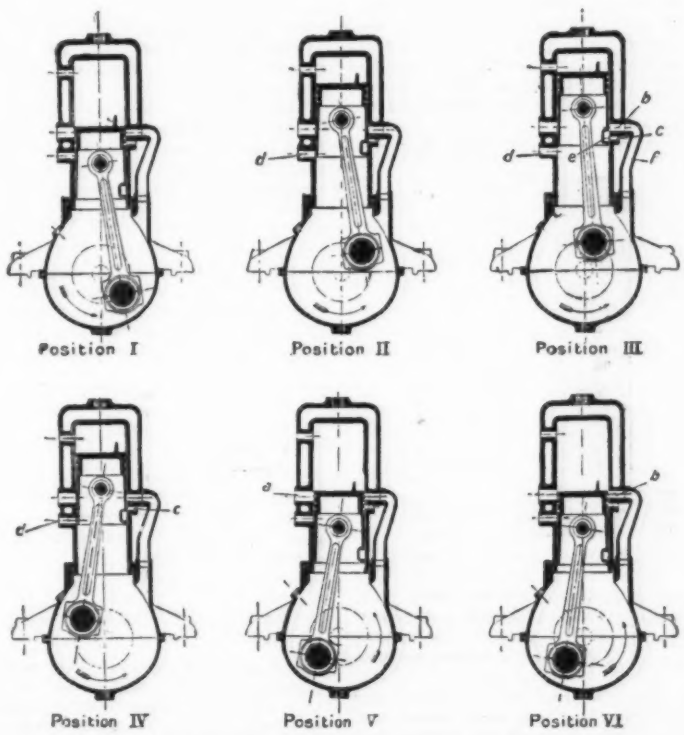
1. *Soft Solder, or Tin Solder.*—Subdivisions of this class are pure tin solder and the so-called bismuth solder. Soft solder is the most fusible kind, requiring, therefore, the least heat for soldering. As a matter of fact, soft solders can be prepared which will melt at a heat below the boiling point of water.

2. *Hard Solder.*—Some very different substances are brought together under this name; but the one distinguishing characteristic of the group is that all its members have a considerably higher fusing point than the soft solders, and thus can be used in soldering articles which are to be exposed to higher temperatures. The principal varieties of hard solder are:

Copper solder.
Brass solder, with its varieties known as hard and soft brass solder, white, half-white, and yellow-white solder.
German silver solder.
White nickel solder.
Soft and hard silver solder.
Gold solder.
Enameling solder.
Aluminium solder.

Several of these solders can be used for soldering other metals than those which the name indicates. It would be entirely possible, for example, to solder German silver with hard brass solder; but as this is yellow and German silver white, the seams would show and give the article a bad appearance.

To have the color of the solder as nearly as possible the same as that of the metal to be soldered, metallic mixtures are used, and it is also an object, as far as practicable, that the alloy should have similar properties. It is apparent that a large number of different solders are necessary, to correspond with the number of different metals and alloys.



THE CYCLES OF THE KOERTING ENGINE.

SOFT SOLDERS.

Soft solder, or tin solder, can be used to solder many different metals, gold, silver, lead, copper, and steel, as well as brass, wrought iron, and zinc. Its principal use, however, is in ordinary tinsmith's work, for which tin plate, zinc, or sheet brass are the materials most frequently employed. Soft solder can be used for any purpose where the soldered articles need not be heated much above the boiling point of water, so that there is no danger of its melting.

In regard to their qualitative composition, soft solders vary but very little. Tin and lead, and sometimes bismuth, are the metals combined. But the proportions of these are varied so much as to make a very large number of different solders. It may be remarked, in general, that the fusing point of the alloy is raised by increasing the contents of tin, and lowered by the addition of more lead. Since lead is much cheaper than tin, alloys containing a large proportion of lead are of course used for objects where a high fusing point of the solder it not necessary, as for instance in making toys. For certain other purposes, solders of pure tin, or those containing but a small amount of lead, are required. This is the case in the soldering of metallic utensils for use in chemical laboratories, or in the preparation of drugs and extracts. These utensils are made either of copper, and tinned on the inside, or of pure tin, which is a good resistant of chemical action. If solder containing much lead were used upon them, the lead would be liable to attack by certain chemical agents, and some amount would be dissolved into the contents of the vessel. In such cases, therefore, no regard should be paid to the cost of the solder; the only consideration should be the prevention of any possibility of attack by substances such as vegetable extracts, fruit juices, etc. Pure tin is the best material for the solder, and it is of importance that it should be the best obtainable. English tin and "Banka" tin rank first with respect to purity, and the fusing point of the metal and the appearance of the fracture may be taken as a standard of the quality. Pure tin melts at 235 deg. C. (455 deg. F.) and the fusing point of a good quality of tin will be very near to this. If the fusing point is more than five degrees higher or lower, there is reason to suppose that there are adulterations which will be liable to affect the solder injuriously.

If the fusing point is lower than 230 deg. C. (446 deg. F.) it is probable that the metal contains a small quantity of lead, usually added intentionally; a rod of such tin, on being bent, will make but little of the peculiar crackling noise characteristic of pure tin, and if broken, the fractured surface will plainly show the difference.

A fusing point above 240 deg. C. (464 deg. F.) will usually be due to small quantities of iron; tin containing iron is hard to bend, and has a hackly fracture. The presence of iron, however, is far less dangerous than that of lead.

For ordinary tinsmith's work, where the resistance of the solder to acids, etc., is of less importance, it is customary to use mixtures of tin and lead, in varying proportions according to different purposes and according to the required melting point of the solder. Experts have taken much pains to make accurate determinations in this important matter, and the following table gives the fusing point (Centigrade) of a solder containing a given amount of lead to 100 parts of tin:

Lead.	Fusing Point.	Density of the Alloy.
16.5	194	7.927
30	194	7.994
33.3	194	8.109
40	194	8.234
45	187	8.267
50	187	8.408
60	181	8.447
66.6	181	8.726
100	197	8.864
119	197	9.038
125	210	9.270
179	210	9.433
200	235	9.554
233	235	9.640
250	235	9.770
268	243	9.797
300	246	9.939
358	246	10.052
536	270	10.331
715	283	10.595
880	292	10.751
1072	292	10.815

It will be seen that the alloys of tin and lead become denser and less readily fusible as the contents of lead are increased.

According to other experiments, the fusing points of the alloys are as given below:

Lead.	Tin.	Fusing Point.
207	118	189 deg.
207	354	180 deg.
207	708	190 deg.
621	236	211 deg.
1242	118	270 deg.

Before the solders really melt, they soften considerably, and the following table gives the softening point of some alloys:

Lead.	Tin.	Softening Point.	Melting Point.
1035	236	185 deg.	189 deg.
1242	236	189 deg.	194—195 deg.
1449	236	192 deg.	198 deg.
1656	236	202 deg.	208—210 deg.

Alloys used especially for solders:

Tin.	Lead.	Fusing Point.
1180	4140	240 deg.
1180	3105	223 deg.
1180	2070	200 deg.
1180	1242	181 deg.
1180	1035	185 deg.
1180	828	190 deg.

Composition of ordinary soft solder:

Lead	207
Tin	118

Weak Soft Solder.

Lead	207
Tin	236

Strong Soft Solder.

Lead	414
Tin	118

Fluid Solder.

Lead	621
Tin	590

Fluid solder is prepared by making the given mixture and letting it stand until partially hardened, when the part which is still fluid is poured off. In using this, it is poured into large seams, and works extremely well. The stiffened part can be used as ordinary solder.

If the alloys are to be made in small quantities, it requires very sensitive scales to weigh the metals accurately. The composition of some varieties of tin solder is given below, in round numbers, with the fusing point of each. They are numbered according to their fluidity, No. 1 being the hardest.

1.	Lead	2
	Tin	1
Fusing point, 240 deg. C.		
2.	Lead	1
	Tin	1
Fusing point, 200 deg. C.		
3.	Tin	2—2½
	Lead	1
Fusing point, 185—190 deg. C.		
4.	Lead	10
	Tin	177
Fusing point, about 180 deg. C.		

Bismuth Solder.—For some purposes even the soft solders of tin and lead are too difficult of fusion, and in this case alloys of tin, lead, and bismuth are employed. This is a most excellent solder, but its use is limited to very special purposes, on account of the expensiveness of bismuth. For ordinary work, also, there is no need of such an extremely low fusing point.

Tin and bismuth alone are sometimes used, but not often. This alloy is more resonant than pure tin, but less ductile. The fusing points of some alloys of tin and bismuth are given below:

Bismuth.	Tin.	Fusing Point. Deg. C.
208	118	(Very brittle.) 137.7
208	236	165.56
208	944	168.99

All solders containing bismuth have a very low fusing point; their disadvantage is that they have but little cementing power, and are very brittle, so that if an article soldered in this way is allowed to fall, the whole soldering seam will often give way. We give below the composition of some of the solders of tin, lead, and bismuth, with their respective fusing points:

Tin.	Lead.	Bismuth.	Fusing Point. Deg. C.
118	207	208	124
236	414	208	145
354	621	208	255
472	828	208	160
236	207	208	160

With a considerable admixture of bismuth, the fusing point can be brought down to a temperature lower than the boiling point of water. Some of these mixtures are here given:

Newton's Metal.

Bismuth	1664
Lead	1035
Tin	354
Fusing point, 94.5 deg. C.	

Rose's Metal.

Bismuth	416
Lead	207
Tin	118
Fusing point, 93.75 deg. C.	

D'Arcet's Metal.

Bismuth	1664
Lead	1656
Tin	354
Fusing point, 79 deg. C.	

Attention should be called to the fact that these readily fusible metallic mixtures are remarkably well adapted to making reproductions of delicate plaster casts. A cast is made, for example, of a beetle. After drying, at 100 deg. C. (212 deg. F.) the insect is carefully removed from the mold, and the latter filled with the fluid alloy. A perfect reproduction will be made.

Bismuth solder is usually made by melting the required quantity of bismuth together with ordinary tin solder, in the proportion of one part of bismuth to eight parts of solder. The tin must be melted first, and heated above the melting point; then the lead is added, the vessel removed from the fire, and the bismuth thrown into the mass, which will at once become thinner. It must be stirred rapidly, and the stirring should be continued until the alloy begins to stiffen, in order to insure an even mixture.

A very good way is to scatter the bismuth, in pow-

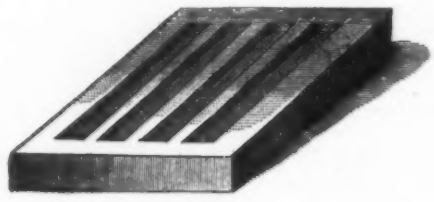


FIG. 1.

dered form, into the melted tin and lead, stirring all the time. Frequent remelting of bismuth solder is to be avoided, since this is apt to raise the fusing point.

Manufacture of Soft Solders.—The correct process of preparing soft solders is very simple, but certain rules must be observed if solder of good quality is to be obtained.

The standard of good quality is that any smallest piece of the solder shall contain all the metals of the mixture in the right proportions. If improperly prepared, some parts of the solder will have a different fusing point from others.

Since lead is harder to melt than any of the other metals used in solder, it ought really to be melted first and the others added to it. The tin, however, is less dense than the lead, and will not sink in it, so that much longer stirring is necessary to insure an even mixture than if the process is reversed. Besides this, the lead oxidizes very easily, and if melted alone, there will be a considerable waste in ash. The following method is the best: Cut the lead into little pieces, and have them ready on a shovel. Heat the tin in a stone or porcelain vessel over a coal fire, gently at first, until melted. When a film of tin-ash forms upon the surface of the metal, throw in the lead, a little at a time, waiting until this is melted before adding more. Stir constantly with a flat wooden paddle, in order that the metals may be thoroughly mixed.

When all the lead is melted, pour the alloy into the molds by means of a ladle with a nozzle. When it has become stiff, dip the mold into cold water, throw out the solder, and have the mold ready for more. Two workmen, with but a small number of molds, can prepare a considerable quantity of solder in this way in a short time.

The forms into which the solder is poured are best made of cast iron, of such a size as to make rods of the solder about 30 centimeters long, 2 to 3 centimeters wide, and 2 to 5 millimeters thick. The sides are inclined outward a little, so that the rods can be easily removed, and the mold is rubbed with grease before being used the first time.

For commercial purposes, and for large factories

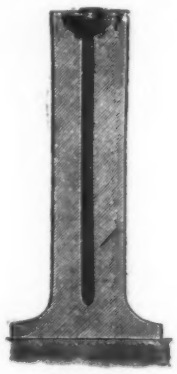


FIG. 2.

where the solder is given out to the workmen, it is well to have the pieces all of the same size and weight. The mold shown in Fig. 1 is especially well adapted to this, and the solder is produced in sharp-cornered prismatic pieces.

In making fine bismuth solder and tin solder for delicate work, it is well to cast it in molds which will give cylindrical pieces. Fig. 2 shows the cross-section of such a mold. It consists of two parts, with half-cylindrical grooves, making a hollow cylinder when placed together. The solder is poured in at the top.

If iron vessels are used to melt the solder, as is frequently done, the solder will take in some iron and become harder and more brittle. Vessels of stone or porcelain are therefore preferable.

Bismuth alloys are made in the same manner as ordinary solder, except that the temperature of the mixture is lowered, by decreasing the fire, immediately after adding the bismuth.

In practice, the quality of the solder is judged by its outward appearance. Good soft solder has a crystalline structure, apparent on the surface, and the crystals are grouped in a peculiar way. These "blossoms," so called in German, are brilliant spots on a dull white ground. If the solder shows very brilliant tin-white specks on a blue-gray ground, this is a sure indication that it was badly prepared, and that the metals are not properly mixed. Solder of this nature can be made over, by melting and stirring vigorously.

If, in spite of correct treatment and intimate mixture by stirring, the "blossoms" are not seen, it is a sign that there is not sufficient tin in the composition. Melted tin in small quantities can be added to the melted mass, until a sample shows the desired crystalline structure.

Special Uses of Soft Solders.—Metal workers who are in the habit of preparing alloys for solders are likely to have occasion to use them for other purposes also. As before observed, these alloys, on account of their low fusing point and the sharpness with which they fill out the forms, are well adapted to the manufacture of small cast articles, such as children's toys, buttons, etc.

If it is desired to make them harder and save tin, small quantities of antimony may be added during the melting. From 1 to 5 per cent is enough to harden the alloy considerably; a certain limit must not be exceeded, for the reason that the articles, especially if thin, would be very brittle and break easily.

An alloy for casting, made of 4 parts of tin and 3 of lead, is easily fusible, and quite soft, filling the forms perfectly. Eight parts of tin, 6 of lead, and 0.5 of antimony makes an alloy easily fusible, but somewhat harder and more brittle than the preceding.

Sheet Alloy.

Tin	35
Lead	250
Copper	2.5
Zinc	0.5

This alloy has a fine white color, and can be rolled out into very thin sheets. It is used for lining tea-chests, and for making sheet to wrap up tobacco, chocolate, etc. The copper and zinc are used in the form of fine shavings, and the alloy cast into thin plates, afterward rolled to the thinness of paper, and called tin foil.

An alloy of 29 parts of tin and 19 of lead is characterized by a high and permanent luster, and can be used to imitate brilliants, for theatrical decoration. An alloy of 2 parts of tin and 1 of lead is usually made first, and more tin is then added until a drop, let fall upon a smooth iron plate, reflects like a mirror. The brilliants are made by dipping a piece of glass, cut in the form of a jewel, into the melted alloy, quickly removing it and letting it cool. The small quantity of the alloy adhering to it stiffens quickly and falls off. These brilliants are rough on the outside and gray in color, but the smooth inner surface, by artificial light, gives reflections like diamonds; the surface may also be coated with blue, red, or green aniline varnish to vary the effect. Pieces of polished steel or bronze may also be used instead of the glass.

The above-described alloys of tin, lead, and bismuth are the ones generally used for casting objects which cannot be exposed to great heat, such as wood carvings, plaster casts, etc.

The so-called *cliché* metals possess in a high degree the qualities of ready fusibility, softness, and capacity for filling out the molds sharply, which are required of these alloys, and are eminently suited for casts of woodcuts, as in making metal plates for printing.

Cliché Alloys.

Tin	3
Lead	2
Bismuth	5

Fusing point, 91.6 deg. C.; excellent for cuts, but expensive on account of the large amount of bismuth. Some cheaper compositions are as follows:

	I.	II.	III.	IV.
Tin	1	3	1	2
Lead	1	5	1.5	2
Bismuth	2	8	3	5
Antimony	..	..	..	1

Alloys for medallions and coins (used by collectors to take impressions) must give extremely fine and sharp impressions. The following mixtures are suitable for the purpose:

	I.	II.
Tin	3	6
Lead	13	8
Bismuth	6	14

Castings of natural objects, such as fruits, leaves, butterflies, lizards, etc., can only be made by using the very softest and most fusible alloys known, prepared by adding cadmium to the bismuth alloys. This metal, whose fusing point alone is 455 deg., has nevertheless the property of lowering the fusing point of metallic mixtures.

Wood's Metal.

Tin	2
Lead	4
Bismuth	5 to 8
Cadmium	1 to 2

This is silver white, very fine grained, and melt

tween 66 deg. and 72 deg. C. It is also excellent for soldering.

Lipowitz's Metal.

Tin	4
Lead	8
Bismuth	15
Cadmium	3

This is the most readily fusible of all mixtures, becoming soft at 55 deg. and melting entirely at 60 deg. C.—Translated from Edmund Schlosser's "Das Löten und die Bearbeitung der Metalle."

PROPERTIES OF THE SERIES TRANSFORMER.*

By W. B. GUMP.

IT is believed by the writer that the characteristics of the series transformer are not so generally known that a few facts relating to it would be out of place, and to those who are concerned with this very useful piece of apparatus the following may, it is hoped, be of some benefit.

In order to have a clear conception of the action of a series transformer, it may be well to point out the more general features which it possesses, and to compare these with the corresponding properties of the potential transformer. Suppose we consider a circuit as shown in Fig. 1, in which current flows through the primary, *P*. The value of this current will necessarily be determined by the load on the line, *L*, irrespective of the condition of the secondary, which might be either short-circuited or entirely open. Observe now the condition shown in Fig. 2, that of a shunt transformer in which the primary is connected directly across the mains, the current being governed by the impedance between *M* and *N*. The current depends

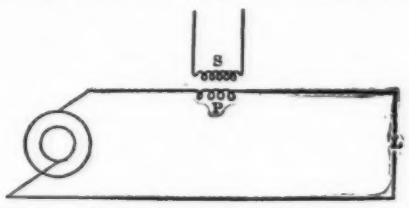


FIG. 1.—PLAIN SERIES TRANSFORMER.

upon the load on the secondary, *L'*, and not upon the line load, as in the first case.

Let us now assume that the secondary in Fig. 1 is on short-circuit, and for simplicity, that there is no magnetic leakage between the coils. At the moment that current is started, flux is set up in the primary. This flux produces an E. M. F. in the secondary which sets up a current opposed to that flowing in the primary. The result is that the flux threading the coils will be reduced to a value which will produce only a sufficient voltage to cause current to flow through the secondary resistance, thus restoring approximate equilibrium between the primary and secondary currents. Thus the magnetomotive force of the primary current is less than that of the secondary current by an amount such that the flux produced thereby generates the voltage required to send the secondary current through the resistance of the secondary circuit, the vector sum of the secondary current and the magnetizing current being equal to the primary current.

Consider now that the secondary is closed through a high resistance. There will be a decrease in the secondary current, and hence a decrease in the ampere-turns, allowing the primary ampere-turns to become effective in producing a greater flux, which will cause the secondary E. M. F. to increase. The increase in the secondary E. M. F. will increase the current in the secondary, which in turn will create an opposing magnetomotive force, the value being just sufficient to allow the excess of primary magnetomotive force to produce the flux to cause the current in the secondary to flow. A further study of these facts will reveal the fact that an increase in the magnetizing current due to an increase in the secondary resistance affects the current ratio between the primary and secondary.

In order to perform its work perfectly, a series transformer should maintain a constant ratio between its primary and secondary currents throughout its full range of load. Such a condition can only be approached, and not absolutely reached, since the magnetizing

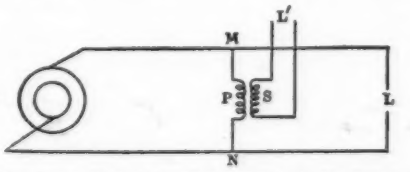


FIG. 2.—PLAIN SHUNT TRANSFORMER.

current becomes a formidable factor in preventing a constant ratio. From these facts it is seen that the first essential in a series transformer is a minimum magnetizing current. This is accomplished in commercial current transformers by having an abundance of iron in the core, thus working the iron at a very low magnetic density—only a small fraction of that of the potential transformer—permitting the current ratio of the primary to the secondary to vary approximately in inverse ratio to the number of turns. The iron is worked considerably below the "knee" of the B.-H. curve, allowing a considerable range of load for ammeters and wattmeters to be operated on the secondary.

Since the ratio between the primary and secondary is not constant for all loads, instruments which are to be operated on the secondary of current transformers are calibrated with the transformer throughout the working range of the instrument, making the scale divisions correspond to the true reading in amperes.

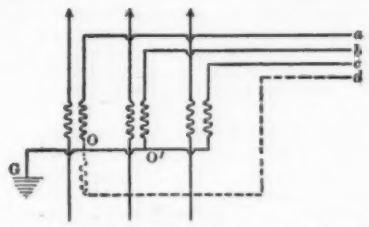


FIG. 3.—SERIES TRANSFORMERS IN THREE-PHASE CONNECTIONS.

It was stated that in order to reduce the magnetizing current to a minimum, the iron is worked at a low magnetic density. Due to the fact, therefore, that a large cross-section of iron is used, the secondary of a current transformer should always remain closed, for the reason that when there is no current in the secondary there is no opposition to the primary magnetomotive force, which may produce a large flux to cause the voltage on the primary to rise to an enormous value, often to thousands of volts. This condition produces serious heating of the transformer as well as great strains upon the insulation, which has in some instances been punctured by the extreme voltage produced.

From the foregoing it is readily understood that a current transformer differs quite widely from a potential transformer, the latt maintaining a practically constant secondary voltage irrespective of load on the secondary, while the former must of necessity change its secondary voltage in order to change its secondary current. In the former we have an approximately constant current ratio governed by the number of turns the secondary bears to the primary. In the latter we have an approximately constant voltage ratio governed by the number of turns of the secondary to the primary. In this we have a striking relation, and as the respective names imply, one transforms current while the other transforms E. M. F.

Having considered the nature of current transformers, the conditions will now be shown which exist in connection with two or more current transformers operating together on a polyphase circuit. Consider first the application of three series transformers as

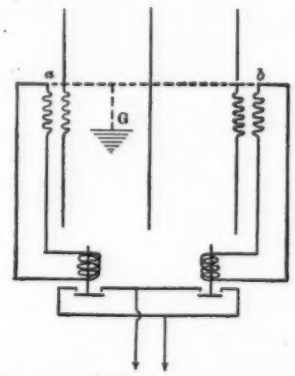


FIG. 4.—DOUBLE COIL RELAY.

shown in Fig. 3, which is quite common in three-phase generating systems of from 3,000 to 12,000 volts. If all of the secondaries are not arranged in the same direction, it will be found that the phase relation between the first and second, and between the second and third, respectively, is 60 deg. instead of 120 deg. As the phase relation does not alter the readings on ammeters, such an arrangement of connections is permissible. To obtain a phase difference of 120 deg. between each, it would be necessary to reverse one of the secondaries, such as *O d*, shown by a broken line. In either a delta or star arrangement it becomes necessary to reverse one transformer with respect to the others when 120 deg. difference of phase is required. When operating three-phase wattmeters, the middle transformer is nearly always dispensed with, since but two are necessary. In such a case a third phase is introduced by reason of a common return wire being brought to the point *O'* from the junction of the other two phases, creating three phases differing from each other by 120 degs.

In connection with overload relays, three transformers are often recommended, but in the majority of cases two are sufficient to give entirely satisfactory results. When two transformers are employed on a relay circuit, the connections shown in Fig. 4 will be found to give satisfaction, as each transformer has its own trip coil, and an overload on any phase is sure to cause one or the other of the trip coils to actuate the switch. If the secondaries are to be grounded they should be connected as shown by *a b*, and thence to the ground, *G*.

A single coil relay is shown in Fig. 5 in which the current transformers have their opposite terminals connected. To these connecting wires a trip coil, *T C*, is joined. The phase relation which exists between the two secondaries may be seen from Fig. 6. Here the secondaries, *S* and *S'*, tend to operate in parallel. When normal current flows in the line conductors, *a* and *c*, a current will circulate in the trip coil, *T C*, but will not be sufficient to actuate the trip coil. Suppose a short-circuit to occur between *O* and *c*. The secondary, *S'*, will become overloaded. Its E. M. F. will, therefore, rise to a value above that of the transformer, *S;* this will tend to reverse the current in *S*, which in turn will allow the primary flux to raise the E. M. F. to that of *S'*. The value of this voltage will cause the additional current to overload the trip coil and actuate the switch.

The current in the trip coil will not be twice the current in either phase *O a* or *O c*, but will be the geometrical sum of the currents at 120 degs. difference in phase, or $\sqrt{3}$ times the current in one leg. Thus if the current transformers, *S* and *S'*, are wound to give 5 amperes on their secondaries with normal current in the primary, the current in the trip coil will be $\sqrt{3} \times 5 = 8.66$ amperes. The tendency of the two transformers connected as shown is to divide the current equally between them, regardless of the phase on which an overload takes place. It is possible, however, for the current in the trip coil to become greater from an overload across *a c* than one across *O c* or *O a*.

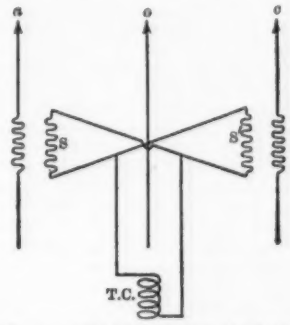


FIG. 5.—SINGLE COIL RELAY.

The impedance in the trip coil will change with change of load, and is a significant factor in opposing the rise of pressure in the two transformers. The opposing force of the trip coil is in every case reacted upon by an effort on the part of the transformer voltage to rise to a higher value to meet the impedance E. M. F. A balance is finally maintained which allows just enough current to flow to overcome the total impedance created.

In connecting power factor meters, care is necessary in order that the current transformers do not produce a geometrical increase in current. If, when connected, the current is found to bear the $\sqrt{3}$ relation, the terminals of one transformer should be reversed.

Although the current transformer is highly useful, and its development has reached a point of great accuracy, there remain some defects which cannot be completely overcome, except by some type of compensating device which from its own character is inaccurate. The impedance produced by the instruments themselves when connected to current transformers, is for the most part corrected by the calibration in connection with the transformer. The greatest errors occur in watt-hour meters, since the errors are carried along, and hence are continually increased, there being a chain of intermediate elements through which the electric energy must travel to be recorded.

Current transformers to be used in operating watt-hour meters must be designed so as to "average up" the errors according to the usual load upon the instrument. Careful design, therefore, eliminates most of the errors and permits of considerable accuracy throughout the range of load being measured.

HEUSLER'S MAGNETIC ALLOY.—Andrew Gray has made some very curious observations in the case of a Heusler alloy containing about 16 per cent manganese, 8

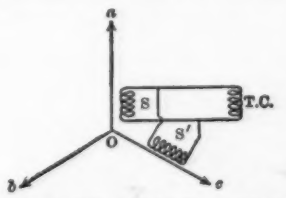


FIG. 6.—PHASE RELATION IN SINGLE COIL RELAY.

per cent aluminium, a little lead, and the remainder copper. It was originally almost non-magnetic. It was heated to 400 deg. C. in a furnace and allowed to cool slowly. After having been placed in a magnetic field it was found to retain a considerable amount of magnetism. It was next heated to 340 deg. C. for about 20 minutes and allowed to cool, when it was found that the magnetic properties were much more pronounced. The magnetic properties were destroyed by quenching from a temperature of 400 deg. C. The effect produced by the temperature of liquid air upon the material in its quenched and, at ordinary temperatures, nearly non-magnetic condition was now investi-

* Electrical World.

gated and found to be very remarkable. When tested at the temperature of liquid air the specimen was found to be more susceptible to magnetism than in its previous best condition, while it exhibited very much less hysteresis and retentiveness. The structure of the alloy is well brought out by etching with ammonia.—A. Gray, Proceedings Royal Society, March 6, 1906.

ELECTRIC SMELTING OF CANADIAN IRON ORES.*

By EUGENE HAANEL, Ph.D.

INTRODUCTION.

THE only experiments which the members of the Commission appointed by the government in December, 1903, to investigate the different electro-thermic processes for the smelting of iron ores and the making of steel in operation in Europe † were able to witness in the electric smelting of iron ores were those made by Dr. Héroult at La Praz, and Mr. Keller, of Keller, Leleux & Co., at Livet, France. The first was a mere trial, furnishing no reliable quantitative results; the latter more extended experiments, continued for a number of days, were made with a very porous hematite containing 3.21 per cent of manganese and only 0.02 per cent of sulphur, an ore, therefore, easily reduced and easily desulphurized. Two sets of experiments were made at Livet. In the first experiment 0.475 E. H. P. years were required per ton of 2,000 pounds of pig iron, corresponding to an output of 5,769 tons per 1,000 E. H. P. days. In the second experiment 0.226 E. H. P. years were required per ton of product, corresponding to an output of 12.12 tons per 1,000 E. H. P. days. In this experiment, moreover, most of the iron produced was white, for which cold working is required and consequently less energy consumed.

The difference in output of these two experiments was so great, being more than double that of the first in the second experiment, that no conclusion could be drawn as to the amount of energy required per ton of product, and Mr. Harbord, the metallurgist of the Commission, was compelled to adopt 0.350 E. H. P. years, the mean of the two experiments, as the probable energy required per ton of product. This would correspond to an output of 7.827 tons per 1,000 E. H. P. days. Before, therefore, a sound judgment could be formed as to the practicability of the electro-thermic process for the smelting of Canadian ores, it was desirable to establish with some degree of exactitude the amount of electric energy required per ton of product, and also the following important points referring to Canadian conditions, which were either not taken up or were left in doubt by the Livet experiments:

First. Can magnetite, which is our chief ore, and which is to some extent a conductor of electricity, be successfully and economically smelted by the electric process?

Second. Can iron ores with comparatively high sulphur content but not containing manganese be made into pig iron of marketable composition?

Third. The experiments made at Livet with charcoal as a reducing agent in substitution for coke having failed, could the process be so modified, that charcoal, which can be cheaply made from mill refuse and other sources of wood supply useless for other purposes, could be substituted for coke? This is especially important since charcoal and peat coke constitute home products, while coal coke for metallurgical processes requires to be imported into the provinces of Ontario and Quebec.

The settlement of these questions was of such paramount importance for the formation of a judgment as to the feasibility of introducing electric smelting of iron ores as an economic process in those provinces of Canada which lack coal for metallurgical coke, but are abundantly supplied with water powers and iron ore deposits, that the experimental investigation of the subject by the erection of an electric smelting plant in Sault Ste. Marie, Ont., was authorized.

DESCRIPTION OF EXPERIMENTAL FURNACE AND ELECTRODE HOLDER.

The furnace, as first designed by Dr. Héroult, consisted of an iron casing ¼ inch thick, bolted to a cast-iron plate 48 inches in diameter. This casing was vertically slit to break the magnetic circuit and render the inductance as small as possible. The gap formed by this slit was bridged over by a plate of copper 10 inches wide, which was securely riveted to the iron casing.

The bottom plate, which formed one of the terminals for the current, had iron rods cast for the purpose of insuring a good contact with the carbon paste rammed in the lower part of the casing to form the crucible.

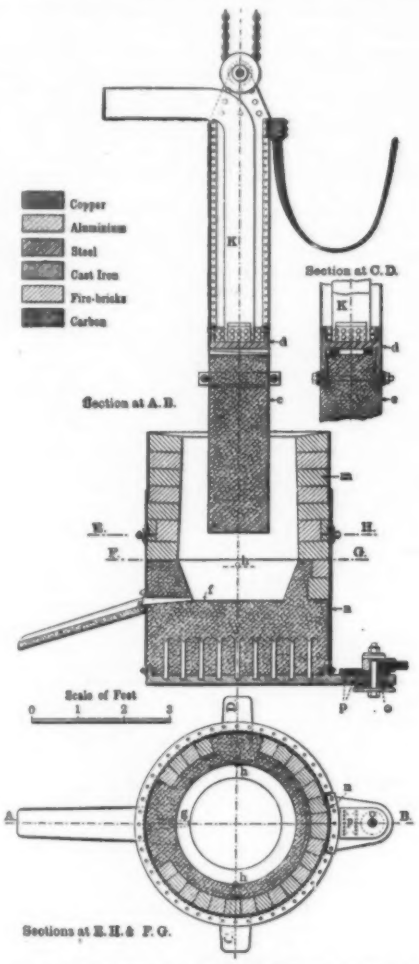
The casing was made in two parts, the lower part being 3 feet and the upper 4 feet high.

The electrode holder was made of four copper plates, riveted together, and to a steel shoe (*d*, see figure) into which fitted the electrode *e*. In this construction the sides of the electrode and electrode holder were flush, which allowed the holder to penetrate the charge without resistance. This was intended to permit of the consumption of the electrode to nearly its full length and obviate the necessity of throwing away from 2 feet to 3 feet of unused electrode, which in any other construction would be the case. To keep the contact cool a pipe *K* was introduced, by means of which air circulation was effected. It was found, however, that to secure proper contact between the steel shoe and electrode a clamp had to be placed around the shoe, the bolts of which in descending into the charge would have offered resistance to vertical regulation of the electrode. This change in the contact rendered the long copper attachment useless.

To utilize as much of the electrode as possible, the height of the furnace was diminished to dimensions shown in the figure, which represent the final modification of the furnace as used for the majority of the experiments made.

The contact did not prove entirely satisfactory, as there was a constant loss of from 2 to 3 volts, but as this loss could not be remedied during the experiments a bolt was screwed into the electrode and connected to a voltmeter, which allowed of the determination of loss of volts by taking the difference between the volts indicated in main circuit and on the electrode.*

The contact with the bottom plate was at first made by driving a conical copper plug into a conical hole in the projecting part of the bottom plate and making contact by pressing the aluminium block (holding cables), copper plug and bottom plate together by means of a bolt. Owing to the oxidation of the surfaces in contact, this method of making contact proved inefficient. A new contact was, therefore, made by turning a copper plug from a block of copper 10 inches by 12 inches, leaving an oblong flange, which was dressed on both sides to make a good bearing. Two rows of holes, *p* (fourteen in all), of ¾ inch diameter



EXPERIMENTAL ELECTRIC FURNACE.

were drilled through the copper flange and into the bottom plate for a depth of about 1 inch, into which was run melted aluminium. This aluminium also filled any crevices which existed between the surfaces of contact. The method of connecting cables to copper plug was the same as that described above.

This contact proved to be fairly satisfactory, although a loss of 1 volt or less was realized.

The lining of the furnace was given the shape of a double cone set base to base. Changes in the dimensions of the interior were made from time to time, as indicated by experience, but during the latter part of the experiments they were as follows:

Diameter of bottom of crucible.....	24 inches.
Height of lower cone.....	11 "
Height of upper cone	33 "
Diameter of joint base of the two cones	32 "
Diameter of top of furnace.....	30 "

The electrodes, manufactured by the Héroult process and imported from Sweden, were prisms of square cross-section 16 inches by 16 inches by 6 feet long. The contact with the cables carrying the electric current consisted of a steel shoe riveted to four copper plates which ended in a support for a pulley. The electrode with its contact was supported by a chain passing under the pulley, one end of the chain being fastened to the wall, the other end passing over a winch operated by a worm and worm-wheel. This formed a convenient arrangement for regulating the electrode by hand.

ELECTRICAL MACHINERY.

The electrical energy was furnished by one phase of a three-phase 400 kilowatt 30 cycle 2,400-volt alternating-current generator coupled by belt to a 300-horse-power 500-volt direct-current motor. A current of 2,200 volts was delivered to an oil-cooled transformer of 225 kilowatts capacity, designed to furnish current to the furnace of 50 volts. The transformer was placed in a separate room in the furnace building, close to the furnace. From the transformer the current was led to the bottom plate contact of the furnace and to the electrode contact by conductors consisting each of 30 aluminium cables 5/8 inch in diameter.

The measuring instruments consisted of a voltmeter, an ammeter, a power-factor meter, and a recording wattmeter. The transformer and electric meters were manufactured by the Westinghouse Electric and Manufacturing Company.

An additional voltmeter reading from 10 to 80 volts, supplied by the Keystone Electric Company, which proved very satisfactory, was also placed in circuit to serve as a check.

EXPERIMENTS.

A number of experiments required to be made to adjust the capacity of the crucible of the furnace to the energy available and to determine the shape to be given to the interior of the furnace to insure easy passage of the charge into the reducing and melting zones. After this, attempts were made to utilize the calorific energy of the carbon monoxide resulting from the reduction of the ore, which in all experiments so far recorded had been wasted. To accomplish this, air under pressure was introduced into the furnace about 12 inches below the upper level of the charge. The carbon of the charge, in the form of coke dust, was mixed with fire clay and briquetted to prevent it from being consumed by the air blast. It was hoped that by thus utilizing the carbon monoxide in preheating the charge and partially reducing the ore the output would be materially increased.

It was found, however, that the great heat evolved by the combustion of the carbon monoxide caused the charge to become sticky and to hang. Nor could this be remedied by stoking, the space between the walls of the furnace and the electrode being too narrow. Moreover, the electrode, although it had been protected with asbestos and iron sheeting, was found after the experiment to have been badly corroded. The furnace was not at all adapted for these experiments, and further attempts in this direction were abandoned. The experiments, however, showed that with a differently constructed furnace, in which the electrode is isolated from the charge, the output might be greatly increased by the introduction of an air blast.

The official experiments were begun about the middle of January, the furnace being in operation night and day, with some few intermissions, until March 5. During that time about 150 casts were made, yielding about 55 tons of pig iron.

The following classes of ore were treated:

1. Hematite (Negaunee).
2. Magnetite from the Wilbur Mine, Ont. (William Caldwell, Esq.).
3. Magnetite from the Blairton Mine, Ont. (Pierce Company, Marmora).
4. Magnetite from the Calabogie Mining Company. (J. G. Campbell, Esq., Perth).
5. Magnetite from the Calabogie Mining Company. (J. G. Campbell, Esq., Perth).
6. Magnetite from the Calabogie Mine. (T. B. Caldwell, Esq., Lanark).
7. Roasted pyrrhotite from Lake Superior Corporation.
8. Titaniferous iron ore from Quebec. (J. G. Scott, Quebec).

The materials for the charge—ore, flux, and carbon—were crushed to pass through a ¾-inch ring and roughly mixed. The composition of the charge in each run, as given in this preliminary report, was slightly modified from time to time by varying the percentage of charcoal and flux.

CHARGING.

In starting the furnace a small quantity of charcoal was placed on the bottom of the crucible and the electrode lowered until an arc was developed between the charcoal and the electrode. The arc was maintained for from 16 to 20 hours to preheat the furnace. The furnace was then filled up with the charge, and by lowering or raising the electrode the current was kept as constant as possible at 5,000 amperes.

In most experiments, when charcoal was used as the reducing agent, the electrode occupied a position of about 16 inches from the bottom of the crucible, and required very little attention.

THE SMELTING OF MAGNETITE.

It was expected that considerable difficulty would be experienced in the smelting of magnetite on account of its conductivity. It was thought that with the furnace in use, in which the electrode was immersed in the charge, the current would disseminate itself laterally from the sides of the electrode through the charge, preventing the current at the reducing and fusion zone from attaining such density as would be required for the high temperature necessary for reduction and fusion. With charcoal as a reducing agent this difficulty was not experienced, nor was the inductance of the furnace increased by the presence of magnetite.

It should, however, be mentioned that the phenomenon of rapid temporary decrease of ohmic resistance of the charge shortly after current is put on, when the charge consists of conductors in the form of small pieces, described by J. Bronn in his article

* Preliminary report of the experiments made at Sault Ste. Marie under government auspices. A paper read before the Faraday Society

† Report of the Commission, Department of the Interior, Ottawa, 1904.

* Later an entirely new contact was made, which proved entirely satisfactory.

No. of run.....	8	13	14	15 (two runs)	16	17	18
Ore treated.....	Hematite.	Magnetite from Wilbur Mine.	Magnetite from Blairton Mine.	Magnetite from Calabogie.	Magnetite from Calabogie.	Magnetite from Calabogie.	Roasted pyrrhotite.
Reducing agent.....	Briquettes.	Charcoal.	Charcoal.	Charcoal and charcoal braise.	Charcoal.	Charcoal.	Charcoal.
Flux	Limestone.	Sand.	Limestone and sand.	Limestone.	Limestone and quartz.	Limestone and quartz.	Limestone.
Length of run.....	12 hrs.	61 hrs. 25 min	65 hrs. 30 min.	23 hrs. 50 min. 16 hrs. 15 min.	38 hrs. 20 min.	43 hrs. 5 mn.	56 hrs. 20 min.
Mean volts on furnace	38.5	35.75	36.06	36.16 35.85	36.5	36.79	36.05
Mean amperes.....	4,856	5,000	4,987	5,000 5,400	4,900	5,000	5,000
Power factor.....	0.919	0.919	0.919	0.919 0.919	0.919	0.919	0.919
Pig iron produced..	2,665 lbs.	12,858 lbs.	11,989 lbs.	4,520 lbs. 2,722 lbs	7,150 lbs.	8,303 lbs.	7,336 lbs.
Output of pig per 1,000 E. H. P. days.	11.57 tons.	11.41 tons.	9.92 tons.	10.21 tons. 9.10 tons.	9.07 tons.	10.30 tons.	7.008 tons.

entitled "Zur Anwendung lose geschichteter Kleinstückiger Leiter für elektrische Heizwiederstände,"* was occasionally observed in some of the runs made. This trouble occurred chiefly at the beginning of a new experiment, before the furnace had acquired its normal temperature. By adding a few shovels of iron ore, omitting flux and charcoal, it was sometimes possible to cause the electrode, which, to keep the current constant, had by hand regulation been elevated, to return to its normal position. In a few instances, however, this method failed, and since the electric installation did not permit the compensation of the temporary increase of conductivity of the charge (Bronn's "Anheizungsphase") by decrease of voltage with constancy of current, the electrode rose to the top of the furnace. In such case it became necessary to melt down the charge and start anew.

If the explanation offered by Bronn is correct, that the decrease of the ohmic resistance during the Anheizungsphase is occasioned by the more intimate contact of the conducting pieces of the charge, due to pressure of escaping gases from the pores of the carbon and the carbon dioxide evolved from the limestone, it is evident that preheating the charge, which might be effected by utilizing the carbon monoxide resulting from reduction, would entirely overcome this difficulty, and the electrode would maintain its normal position throughout the operation, required to be lowered only to keep step with its consumption.

THE USE OF CHARCOAL AS A REDUCING AGENT.

It was of great importance to ascertain whether charcoal without being briquetted with the ore could be used instead of coal-coke. No difficulty whatever was experienced; in fact, so admirably adapted was charcoal, when crushed to pass a ¾-inch ring, as a reducing agent in the electric furnace, that coke and briquettes of coke with clay were abandoned, and all the experiments with magnetite and roasted pyrrhotite described were made with charcoal. Some of the charcoal available was of very poor quality, some of it being little better than charred wood containing only about 56 per cent of fixed carbon. This, and the fact that a considerable quantity of the charcoal was consumed on top of the furnace, account for the large quantity of charcoal used per ton of product. A modification of the furnace, protecting the upper layer of the charge from the atmosphere, and the use of charcoal properly carbonized, would decrease considerably the amount of charcoal which was actually used in the experiments, and consequently reduce the cost of production as given.

CONSUMPTION OF ELECTRODE.

For the production of 42,711 pounds of pig iron 384 pounds of electrode were consumed, the same electrode having been in commission for thirteen days.

Consumption of electrode per ton of pig iron:

$$\frac{384 \times 2{,}000}{42{,}711} = 17.98 \text{ pounds.}$$

During the time this electrode was in commission the material in the furnace was melted down several times, exposing the red hot electrode to the oxidizing atmosphere. The consumption of electrode was found to be greater for white iron than for gray iron, and since the 42,711 pounds of pig iron produced included several casts of white iron, the consumption of electrode was on that account greater than it would have been had only gray iron been produced.

POWER FACTOR.

The power factor of the furnace was determined by Mr. Charles Darall, of the Canadian Westinghouse Company, of Hamilton, Ontario, and was found to be 0.919. This high power factor is due to the construction of the furnace casing, as described above.

Since the true electric power is the apparent electric power multiplied by the power factor, it is evident that any error made in the determination of the power factor which tends to decrease its value will appear to decrease the consumption of energy per ton of product. The large output of 12.12 tons per 1,000 electric horsepower days—i. e., the small amount of electric horsepower absorbed per ton of product in the second Livet experiments—was obtained in a furnace with the abnormally low power factor of 0.564. Whatever doubt may be engendered as to the correctness of the figure obtained for the absorption of electric energy on account of this low power factor of the Keller furnace, such doubt cannot arise regarding the figures obtained with the Héroult furnace for the absorption of electric energy in the government experiments on account of its remarkably high power factor 0.919.

Moreover, since the cost of alternate-current generators increases with increase of capacity, furnaces with high power factors (which can utilize a high percentage of the capacity of the generators) will be more economical as regards the first cost of the electrical installation of an electric smelting plant than furnaces with low power factors.

* Elektrotechnieche Zeitschrift, 1906, Heft 9.

MODIFICATION OF EXPERIMENTAL FURNACE FOR COMMERCIAL PRODUCTION OF PIG IRON.

Probably the largest unit which can at present be constructed on the model of the experimental furnace will not exceed 1,500 E. H. P. The construction of the experimental furnace to fit it for the production of pig iron on a commercial scale will require to be modified in the following important particulars:

1. The top of the furnace requires to be modified to permit of the application of labor-saving machinery for charging.

2. Provision requires to be made for the collection and utilization of the carbon monoxide produced by the reduction of the ore; this involves also the protection of the charcoal of the charge from combustion on top of the furnace.

The greater capacity insuring less loss of heat by radiation and the modification of the furnace to permit of the utilization of the carbon monoxide will materially increase the output beyond that ascertained by the experimental furnace. The experiments indicated that under normal conditions about 11.5 tons were produced by an expenditure of 1,000 E. H. P. days. (See runs Nos. 8 and 13.) It is, therefore, not unreasonable to assume that under similar conditions with a properly constructed plant the output per 1,000 E. H. P. days would certainly reach 12 tons. This figure has been adapted in calculating cost of production per ton of pig.

The protection of the charcoal of the charge from combustion on top of the furnace will materially decrease the amount of charcoal necessary for reduction and consequently lessen the cost of this item. This saving has, however, not been taken into account in the estimate of cost.

On account of the value of the product, the smelting of roasted nickeliferous pyrrhotite by the electrothermic process, as carried out with the government experimental plant, admits of immediate commercial application without other modification of the furnace than increase of its capacity.

GENERAL REMARKS.

The ores treated, with the exception of the hematite and the roasted pyrrhotite, contained a high percentage of magnesia, producing a very infusible slag. When the furnace had been running for some time this infusible material formed a scale around the crucible, the electric energy available not being sufficient to keep it in a molten condition. The crucible and lower part of the furnace were, therefore, partially filled up, preventing easy access of the charge to the reducing and melting zone. This slower feeding left the charcoal on top of the furnace exposed to the air a longer time, thus increasing the amount of charcoal required and decreasing the output. With a greater current than was available and consequent higher temperature, the formation of the scale would have been prevented and the output correspondingly increased.

The electric installation at our disposal was far from ideal for electric smelting experiments. Aside from the drop of voltage due to the frequent slipping of the belt connecting motor and generator, it was impossible to increase the current beyond 5,000 amperes at from 35 to 40 volts. This inelasticity of the system prevented the determination of the most suitable current and voltage for a given charge in the furnace.

SUMMARY OF THE RESULTS OF THE EXPERIMENTS.

1. Magnetite can be as economically smelted by the electro-thermic process as hematite.

2. Ores of high sulphur content not containing manganese can be made into pig iron containing only a few thousandths of a per cent of sulphur.

3. The silicon content can be varied as required for the class of pig iron to be produced.

4. Charcoal, which can be cheaply produced from mill refuse or wood which could not otherwise be utilized, can be substituted for coke as a reducing agent, without being briquetted with the ore.

5. A ferro-nickel pig can be produced practically free from sulphur and of fine quality from roasted nickeliferous pyrrhotite.

6. The experiment made with a titaniferous iron ore containing 17.82 per cent of titanic acid permits the conclusion that titaniferous iron ores up to perhaps 5 per cent titanic acid can be successfully treated by the electric process.

Estimate for a 10,000-Horse-Power Plant * producing 120 Tons of Pig Iron per Day of 24 Hours.

Furnaces, contacts, overhead work	$24,500
Bins, chutes, elevators	14,000
Crushers	4,000
Hoists and regulators	10,500
Instruments	1,400
Cables for conductors	8,400
Building	10,500
Mixer and casting machine.....	10,000
Traveling crane and tracks.....	5,000
Ladles	1,500
Slag trucks	3,000
Ore bins	3,000
Repair shop	5,000
	$100,800
Charcoal plant	50,000
Power plant (assuming cost of developing 1 H. P. = $50.00)	500,000
	$650,800
Electrode plant	6,000
Unforeseen expenditure	43,200
	$700,000
Amortization, 5 per cent.. / Depreciation, 5 per cent... / Interest, 5 per cent.....	15 per cent on $700,000 = $105,000.

On a production of 43,200 tons per year of 360 days per ton of pig iron, $2.43.

Cost of Production per Ton Pig Iron:

Ore (55 per cent metallic iron) at $1.50 per ton..	$2.70
Charcoal, ½ ton at $6 per ton.....	3.00
Electric energy, amortization, etc.....	2.43
Labor	1.00
Limestone	0.20
18 pounds of electrode at 2 cents per pound....	0.36
General expenses	1.00
Total	$10.69

In the report complete chemical analyses are given and the results obtained in a number of runs of which the above table is a summary.

* This estimate is given on the authority of Dr. P. Héroult.

A NOVEL MICROPHONE.

THE working of a microphone is known to be based on the fact that the differences in pressure produced between a membrane and a movable contact under the action of the sound vibrations of the former, will result in alterations in the electrical resistance of the circuit, which alterations in turn produce variations in the intensity of the current traversing the microphone. These current variations finally induce in the telephone currents reproducing the words spoken into the microphone.

It will be readily understood that by augmenting the number of contacts more intense effects should be produced. In fact nearly all the microphones at present in use are of the multiple-contact type. Now, as the contacts are mostly arranged behind the membrane, the increase or decrease in pressure will be utilized only on that side, while the membrane, swinging back after each deflection beyond its position of rest, would exert an exactly similar action, though of opposite direction, on a contact placed on the other side of it.

Endeavors have been repeatedly made to utilize this double action. However, as the alterations in resistance on either side of the membrane could not be equalized, the reproductions given by these apparatus were far from being pure.

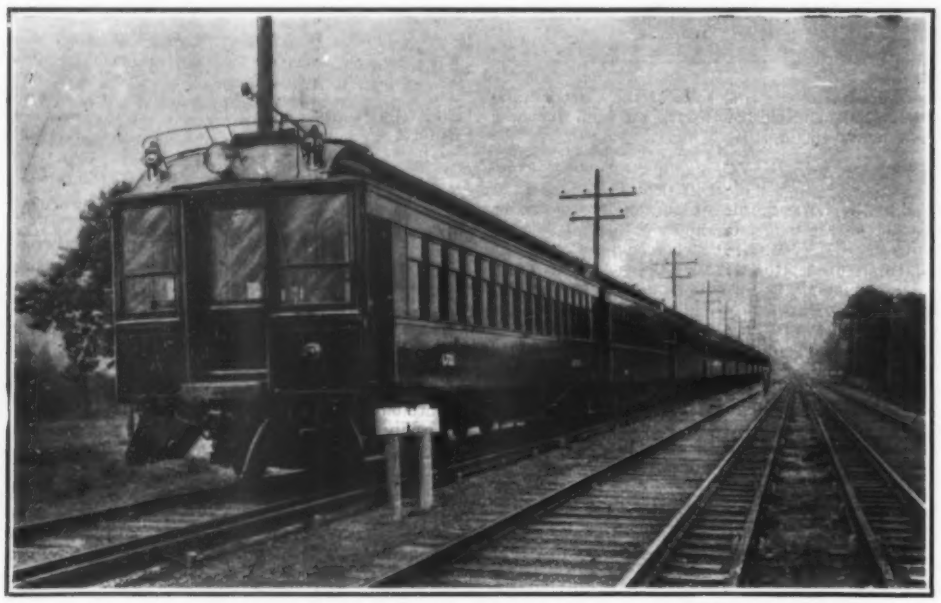
A Swiss company has just patented an excellent double-effect microphone, which is especially fit for use on long-distance lines. Whereas in ordinary city systems no special apparatus will be required, this will become imperative in communicating between distant stations, owing to the high resistance and other disturbances then obtaining.

The novel microphone comprises a membrane compressed by springs against a projection of the microphone box, and in front of which there is fixed, close to the sound opening, a metal plate having a hole in its center. This plate carries inside (that is to say, toward the membrane) a certain ring with numerous hollows filled up with carbon balls. On the other side of the membrane a carbon disk has been arranged having similar hollows, filled up with similar carbon balls. If the membrane of the apparatus be arranged vertically, the carbon grains on both sides of the membrane will be applied readily against the membrane, insuring the electric contact as in ordinary microphones. The mutual connections between the various parts of the apparatus are such that the current arriving from the battery is, when arriving at the membrane, divided into two branches, one of which traverses the carbon grains on one side of the membrane and the other those situated on the other side.

The induction coil comprises two primary windings, constituting the two branch circuits, and surrounding the core of the coil in the same sense. As these windings communicate with opposite poles of the battery, their inductive effects on the secondary coil will be opposite to each other. The action of the ring consists in concentrating the sound waves striking the membrane in the center of the latter, so that the acoustical vibrations of the membrane will spread in concentrical circles, striking the contacts of one side in a constant direction and with invariable intensity, whereas the effect on one side is always opposed to that of the contacts on the other side. An increase in pressure and accordingly a diminution in resistance on one side of the membrane thus corresponds with a diminution in pressure and an increase in resistance on the other side, and *vice versa*. The alterations in current intensity resulting herefrom must be identical in the front and back contacts, the deflections of the membrane on either side of it being exactly the same.

THE ELECTRIFICATION OF THE WEST JERSEY AND SEASHORE BRANCH OF THE PENNSYLVANIA RAILROAD.

THE Pennsylvania Railroad has equipped for electric operation its West Jersey and Seashore Branch, involving the electrification of a main line double-track steam road from terminal to terminal of a greater length than any electrified steam road in the country.



MOTOR-CAR TRAIN ON THE WEST JERSEY AND SEASHORE RAILROAD.

This undertaking also involved the construction of a power house of original design and built in record time. The site for it was chosen on January 17, 1906; the first pile was driven two days later, and on July 1 the first train to take current from the power house was run on the newly electrified tracks. On September 18 the line was placed in operation.

The line of the electrified system extends from Camden, N. J., *via* Newfield, to Atlantic City, a distance of sixty-five miles, and from Newfield to Millville, a distance of ten miles. In addition to the erection of a power house, this work has called for the building of eight sub-stations, one of which is in the power house, the electrical equipment of approximately 150 miles of single track, the building of seventy-one miles of duplicate high-tension transmission line, and the construction and electrical equipment of sixty-eight cars.

Beginning at the Camden end of the line, an entirely new terminal has been constructed, which adjoins the present ferry terminal. The work at this point includes a number of stub end tracks with suitable sheltered platforms between them; and three-quarters of a mile of new elevated double-track trestle, with stone piers and steel superstructure at street intersections, has been built to connect this terminal with the existing lines, at grade, at a point near Haddon Avenue. From a point about two miles from Atlantic City a new right of way has been secured, and after crossing the thoroughfare on a new drawbridge the tracks cross the Philadelphia & Reading on an elevated structure, which includes nine concrete piers with steel superstructure, and enter the Atlantic City terminal on a descending grade. This terminal is new, and, like that at Camden, consists of a number of stub end tracks with concrete platforms between them, with steel umbrella shelters. It is located on the south of the present steam road terminal. From Camden to Atlantic City the road has been electrified with a third rail, with the exception of a stretch of track 4.4 miles in length between Haddon Avenue and South Gloucester, the track passing through the city streets at grade between these points being equipped with the overhead trolley.

In addition to this through route, the line from Newfield to Millville—ten miles—has been electrified. On this portion of the road the overhead trolley has been installed. New terminal facilities have been provided here, including 100 feet of umbrella shelter sheds.

The line from Camden to Atlantic City is a double-track road throughout, and is a three-track road between Camden and Woodbury. From the Camden terminal to Newfield the road is laid with 100-pound rails of the Pennsylvania Railroad standard cross-section, and from Newfield to Atlantic City it is laid with 85-pound rails of the A. S. C. E. section. The line from Newfield to Millville is a single-track road, and is laid with 100-pound rails of standard Pennsylvania Railroad cross-section.

It will be noticed on the map that the Pennsylvania Railroad Company has two roads connecting Camden with Atlantic City, and it is the longer of these routes that has been electrified. This has been done because there is a large local traffic on the longer route, that can be handled more economically and expeditiously by electric traction than is possible with steam haulage. The importance of the undertaking is further emphasized by the density of the traffic on the electrified section of the road. The power house and sub-station equipment and the line are laid out with a view of supplying sufficient power for the operation of all the cars now provided, operating an express service to Atlantic City consisting of three-car trains running on a headway of fifteen minutes in each direction at a speed on a straight level track of sixty miles per hour, and for a local service of two-car trains between Camden and Millville on half-hour intervals, and single cars between Camden and Woodbury on ten-minute intervals. The initial schedule that has been put into service includes three-car express trains between Camden and Atlantic City on one-hour intervals, the running time being ninety minutes, and a local service of two, three, and four-car trains run on a minimum interval of fifteen minutes during the rush hours between Camden and Glassboro, every fourth train going on to Millville. The motor baggage and mail cars are attached to the passenger trains as conditions require. It should be mentioned that each car in the electric service is a motor car, no trailers being used.

The electrical equipment throughout is of standard General Electric design. The general scheme of electrification consists of generating A. C. power at a potential of 6,600 volts at the power house, where it is stepped up to 33,000 volts. At this latter pressure it is transmitted over the high-tension transmission lines to the sub-stations, where it is reduced to a potential of 430 volts by means of step-down transformers, and then led to the rotaries and converted to direct current at 650 volts, at which pressure it is fed to the third rail for operating cars.

INTERIOR VIEW OF THE POWER HOUSE.

The power house is situated at Big Timber Creek, just to the north of Westville, N. J., at a point 5.6 miles from the Camden terminal, where there is an abundance of water for boiler feed and condensing purposes.

For the sake of brevity, the main portion of the electrical equipment of the power house is given below in tabular form:

Three 2,000-kilowatt, 6,600 volt, 25-cycle, three-phase Curtis turbo-generators.

Two 75-kilowatt, 25-cycle, air-blast transformers.

Three blowers; capacity of each, 20,000 cubic feet per minute.

The switchboard consists of:

Three three-phase generator panels.

Two exciter panels.

Three blower motor panels.

One synchronizing equipment.

Three 33,000-volt transformer panels.

Two sets lightning arresters and switches.

Six static potential indicators.

Two 33,000-volt outgoing line panels.

It will be seen from the above that the present normal capacity of the generating station is 6,000 kilowatts. However, there is sufficient room provided in the layout of the building for an additional 2,000-kilowatt turbo-generator set, together with the necessary auxiliaries. The foundation for the extra turbine is already built. In addition to this provision for extra power, one of the end walls of the station is of a temporary nature, in order that increasing demands for power may be met with a minimum of expenditure in the future.

The boiler house is furnished with twelve Stirling water-tube boilers arranged in pairs forming six batteries. Each boiler is rated at 358 horse-power, and is furnished with a superheater capable of delivering steam at 175 pounds pressure and a temperature of 125 deg. F. in excess of that of saturated steam.

The high-tension three-phase current is reduced in pressure and converted to a direct current at 650 volts in eight sub-stations distributed along the line.

The equipments in the several different sub-stations vary according to the requirements of the portion of the road they supply.

The rotary converters are all of standard General Electric design, and are capable of running at 150 per cent full load for two hours with a temperature rise not exceeding 55 deg. The transformers are all supplied with taps giving one-third and two-thirds of the working voltage, to enable converters to be started from the A. C. side. This method of starting needs no synchronizing, and should the D. C. polarity of the machine chance to come in the wrong direction, it is readily changed by means of the field reversing switch provided for this purpose. By this method any of the rotary converters can be started, run up to full speed, and be delivering power to the line within a minute.

It is a matter of interest that the sub-station buildings, including the foundations, were built in sixty working days, and that the installation of machinery was accomplished in thirty working days. The sub-contractors for the sub-station buildings were Messrs. Lynch Brothers, of Philadelphia, Pa.

A unique feature of the transmission line is the method of protection from lightning, which consists of a seven-strand galvanized steel cable 5-16 inch in diameter, strung for the entire length of the line on top of the transmission poles, four feet above the nearest active wire, and provided with ground connections at every fifth pole. This form of protection from lightning is believed to be an efficient supplementary adjunct to the arresters. In all there are seventy-one miles of transmission line. This was erected at a speed of from one-half to two miles a day, the work including the digging of holes and pole erection, besides the stringing of six wires and tying them in position to their respective insulators.

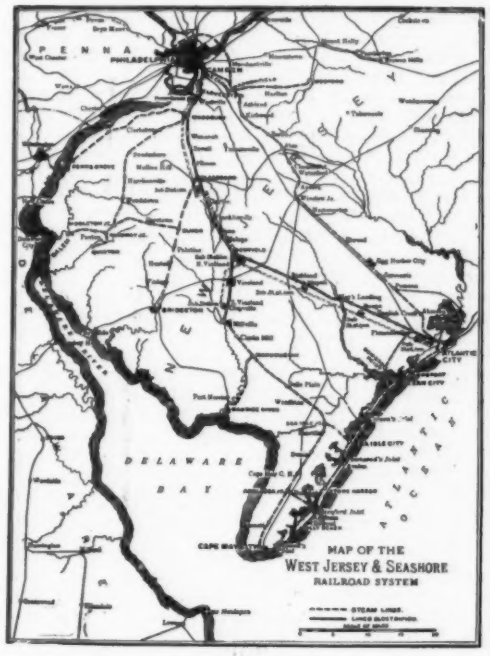
The proposition of installing the third rail for the

double-track road of this length in the prescribed time demanded a considerable amount of skill on the part of those organizing the work; and the fact that a large amount of steam traffic and double tracking was going on at the same time, materially adding to the difficulties of the undertaking. At all stations and in the Atlantic City and Camden yards, the third rail is protected by a wooden top and side guard. This consists of a two-inch plank carried on castings attached to the top of maple posts, which are secured to the third rail at intervals of about six feet. Opposite all platforms the rail is further protected by a plank fastened to the side of the rail. Wherever possible, the rail is kept between the tracks, and is therefore on the side of the track farthest from the station platform, and intertrack fences are provided to prevent crossing the tracks. In order to prevent passengers or others on the platforms from touching the contact shoes on the platform side of the car, there is a protection plank similar to the third rail protecting plank, but carried on castings fastened to the ties. The shoes are at all times under this plank, and therefore protected. This is used at all stations, even where the third rail gives way to the trolley, although there is a switch on the car switchboard, which enables the contact shoes to be cut out when operating from the trolley.

At Atlantic City, where the tracks cross the thoroughfare, a new drawbridge has been built. The third rails on this draw are connected to the third rails on the approaches by sliding contact shoes, so that when the draw is closed the rail is continuously connected. In addition to this, two 1,000,000-circular-mils submarine cables are provided connecting the rails, so that the opening of the draw does not interrupt the circuit. The submarine cables for the return circuit are bare. A point of great interest is to be found in the fact that the third-rail system has been adopted at both terminal stations, where there are a number of platforms, and it will be interesting to engineers to learn that this system was adopted on the score of less difficulties being encountered in its installation than would have been the case had an overhead trolley been erected.

The bonding of the main track between Camden and Atlantic City was a work of great magnitude, which will be appreciated when it is remembered that a heavy steam traffic was in progress during the whole period. It is a matter of interest to know that all the holes were drilled by hand, and also that the bond terminals were expanded by means of screw compressors. Two bonds of the "concealed" type were used per joint, each with a capacity of 400,000 circular mils, and on account of the large size of bonds special angle plates had to be provided. As the road is double-track throughout on the main line, the rebonding required the drilling of a prodigious number of one-inch holes.

For initial service sixty-two passenger cars and six combination baggage and mail cars have been provided. All of the cars are motor cars, the motor and central equipment being the same on all. In preparing the design of these cars, the engineers of the railroad followed the general design of the standard Pennsylvania



MAP SHOWING ELECTRIFIED PORTION OF WEST JERSEY AND SEASHORE RAILROAD.

VIEW SHOWING INTERIOR OF ONE OF THE MOTOR CARS.

Railroad coaches, except that the height is less than the standard to decrease the weight, the shape of the roof is changed, and the interior finish is of mahogany instead of oak. The seating capacity is fifty-eight passengers. Both ends of the cars are provided with vestibules, and have the standard arrangement of steps, trap doors, and vestibule side doors, with standard equipment of bronze hardware and grab handles. The vestibule center door is so arranged that when it opens, it slides over and incloses the control apparatus. All cars are provided with a 50-candle-power incandescent electric headlight and two electric markers or route lamps on the hood at each end.

The cars are equipped with hand brakes and with Westinghouse quick-service automatic air brakes, schedule "AMT." This brake schedule includes the brake valve, brake cylinder, triple valve, feed valve for reducing main reservoir pressure to 70 pounds, the brake pipe for train line, switches, gages, reservoirs, etc., together with what is known as the control line. This line extends through the train, and besides insuring uniform pump labor on all cars, provides, in connection with other apparatus, for the graduated release. The motorman is able to divide the process of release into as many steps as may be desired, securing the same flexibility as with straight air. The quick recharge feature automatically maintains the auxiliary reservoir pressure through three separate feed ports, so that any number of brake applications can be made in quick succession without depleting the system. It also includes a quick-service feature, so that in service applications communication is established between the brake cylinder and brake-pipe pressure, which materially assists in the auxiliary reservoir to build up brake cylinder pressure in the ordinary manner.

The electrical equipments were furnished and installed by the General Electric Company. There are two G. E.-69 motors, which are 200-horse-power units, on each car, while the control system is of the Sprague-General Electric automatic multiple-unit type. The controllers are so arranged that current is cut off from the motors throughout the train and the brakes are applied automatically should the motorman release his hold of the controller handle. A large portion of the electrical apparatus was installed on the car bodies during their construction at the works of the three car builders. All the cables for the electrical conduits are run in grounded loricated conduits, the outlets of which are provided with rubber bushed bell-mouths.

LINOTYPE METAL.

THE extensive use which has been made of linotype machines for typesetting has caused a corresponding demand for linotype metal. The machine is a complicated piece of mechanism, one of the most complicated of any known mechanical appliance; and in order that it shall work regularly and uninterruptedly, the metal that is used must be especially adapted for the purpose. It will not suffice to use an irregular assortment of white metal, but the linotype mixture must be of a standard never changed.

A good linotype metal must have the following characteristics:

1. It must melt at as low a temperature as possible.
2. It must be quite fluid when melted as it has to pass through a small orifice into the mold. Thick metals will clog the gate.
3. The metal must be hard so that the letters will not become flattened in the press.
4. It must fill the mold so that the letters will come out clear and sharp.

Ordinary type metal, used for making printers' type, will not answer the purpose, as it contains too much antimony. This causes the melting point to be too high and the metal chills in passing through the gate. In order to have all of the above qualifications, the linotype metal should not contain too much antimony and must also contain some tin.

It has been found that the following mixture is quite suitable for linotype metal and is extensively used:

	Pounds.
Lead	83
Antimony	12
Tin	5

Only the best quality of metals should be used as a linotype metal which produces much dross in melting is unsatisfactory.

Antimonial lead is generally used for making linotype metal as the antimony which it contains is cheaper than pure antimony. If desired, the following mixture, using antimonial lead, may be used:

	Pounds.
Lead	35
20 per cent antimonial lead	60
Tin	5

The following analysis of some linotype metal was made and will indicate that the composition runs pretty close to the preceding formula:

	Per cent.
Lead	82.29
Antimony	12.59
Tin	5.12

Linotype metal cannot be made without the use of tin, as a mixture of lead and antimony alone will not run sufficiently free. The linotype machine casts a full, solid line of type. Such lines are called "slugs." Most periodicals are now printed from type set on the linotype machine, as the cost is only about one-quarter of setting the type by hand. The slugs are melted over again when the newspaper or magazine has been completed.—Brass World.

A subject of great chemical interest and botanical importance which has come into prominence is the production of prussic acid by plants, which it is convenient to refer to as cyanogenesis. During the first British expedition to the Soudan against the Mahdi a number of transport animals were poisoned through eating a small vetch which springs up in the Nile Valley during the fall of the river. The plant (*Lotus arabicus*) is well known to the Arabs, by whom it is cut when fully grown, and used as a fodder for animals. The results of the investigation of this matter which were communicated to the Royal Society proved that the young plant generated prussic acid when crushed with water. It was found to contain a new glucoside lotusin, together with an enzyme capable of decomposing it into prussic acid, dextrose, and a yellow coloring matter, lotoflavin. The glucoside is of special chemical interest, as being the only one known which contains the cyanogen group attached in the molecule to the sugar residue. Further investigation has shown that other fodder plants which are occasionally poisonous owe this character to the existence of other cyanogenetic glucosides. In a series of papers communicated to the Royal Society, Dr. Henry and Prof. W. Dunstan have described the properties and constitution of dhurrin from *Sorghum vulgare*, and of phaseolunatin, which we have shown to be responsible for the production of prussic acid by *Phaseolus lunatus* (Lima beans), *Manihot utilissima* (cassava or tapioca), and by linseed (the flax plant). Phaseolunatin is remarkable in furnishing acetone as one of its products of hydrolysis. The investigation, besides fulfilling the primary purpose for which it was carried out, has raised a host of problems—as to the constitution of glucosides, the nature of the enzymes which accompany them in the plants, and also in relation to the fundamental question of plant metabolism.

A NATIVE STEEL-SMELTING VILLAGE IN WEST AFRICA.

By the English Correspondent of SCIENTIFIC AMERICAN.

On the occasion of one of his memorable expeditions to the internal countries of Africa, Capt. Grant, the eminent explorer, discovered in the very heart of the Dark Continent a complete ironmaking plant which had been in use from time immemorial by the natives for the smelting of iron in the manner practised by the ancients. Other traces of the familiarity of the savage races of this continent with the production of iron have been found in various African districts from time to time, but Mr. C. V. Bellamy, F.G.S., M.Inst.C.E., the director of public works in the British West African colony of Lagos, is the first to advance us any authoritative and technical details of the primitive methods adopted by these unsophisticated people, since he has been enabled to follow the various processes from the obtaining of the crude ore to the production of the finished steel at an interesting flourishing native settlement situated in the heart of the Lagos colony. It is a curious circumstance that this interesting link between the ancient methods of producing steel and the modern processes as followed at the great steel centers of Europe and America is only some twenty days' journey from the Old World.

This interesting settlement was first discovered by a Baptist missionary, the Rev. Mr. Pinnock, residing at Oyo, the capital of the Yoruba country, and the seat of the king or alaffin of that nation, some two years ago. Subsequently, the missionary communicated the intelligence to Mr. Bellamy, who decided to visit the settlement and study the methods upon the spot in company with Mr. J. E. Stone, an official of his staff in the public works department at Lagos.

The village of Ola-igbi, as this native settlement is called, is situated in the hinterland of British Lagos and is about three days' journey from the coast. Before embarking upon the expedition, permission was sought from the native monarch, as an act of courtesy, and to facilitate the object of the investigators, which assistance was readily granted. The route followed was from Lagos to Ibadan, which is connected to the sea coast by 126 miles of railroad. Oyo is, then, some 35 miles farther on to the north, and the village of Olo-igbi is still farther north, being separated from the capital by extensive bush country typical of this part of the continent. From Oyo the track is a primitive one, the country being practically barren and uncultivated, with the exception of a few acres of ground devoted to the raising of cotton, maize, yams, and so forth. Transport is difficult, owing to the narrowness of the bush-track through undulating country. The soil from time to time gives evidences of the presence of hematite or specular iron. After traveling for some four and a half hours the fumes of charcoal burning were observed, which pointed to the approach to the village. In order not to alarm the natives, couriers were dispatched in advance, giving warning of the approach of the party, and the well-wishes of the king, special emphasis being laid on the fact that the mission was exclusively a pacific one. Such precautionary methods are necessary, since upon the intrusion of strangers in their country, the natives will always flee from their homesteads and seclude themselves in the bush until the visitors have passed. In this case, however, the natives' suspicions were allayed, and when the party arrived, after traveling some 17 miles, they were welcomed with typical native hospitality.

The village possessed a population of about 120 souls. With the exception of the cultivation of a few acres of ground for the raising of cereals and foodstuffs for their own consumption, the whole community is devoted to the iron industry, men and women, and even children of the tenderest age, participating in the enterprise. According to the information vouchsafed by the headman, or balé, of the community, this particular tribe for countless generations has been engaged in the iron industry. Their settlement at Olaigbi, however, is quite recent, dating from about 1899. Anterior to that date they were located close to the small village of Menea, between Oyo and Ibadan, but they emigrated to the present site as the iron was found to be of better quality and easier to work.

The settlement is pitched quite close to the River Omi, a tributary of the Ogun, and which bifurcates just below the village. On the ground between the two waterways, which are dry during the summer season, the smelting houses are situated. The system practised for the extraction of the ore is very similar to that practised by the ancients in the mining of tin in England in the Phœnician era. It may be best described as "placer" mining, the ferruginous deposit being encountered at a depth of 8 feet at the most below the surface, and occurs in a shale closely associated with the neighboring gneiss rock. This shale is much broken up, is soft, friable, and laminated, the laminæ suggesting alluvial influence. There is a layer of gravel about 6 feet in thickness above the shale which is heavily impregnated with nodular particles of hematite iron combined with a reddish clay.

The natives excavate the shale by means of a rudely fashioned pick, being removed in lumps weighing from three to five pounds, and these pieces are carried away to the smelting works for the preliminary treatment. The shale is first roasted over fires of green timber comprising logs varying from 6 to 9 feet in length and 9 or 10 inches in circumference piled in a heap and with the crude pieces of ore laid on top, the quantity of ore to each fire being about a barrowful. This fire is generally kindled over night, about sunset, and then left all night unattended. In the morning the ore is ready for treatment and is pounded up in large wooden mortars by means of heavy wooden pestles, similar to those requisitioned for grinding up corn. This pounding is carried out by women and children, the latter being pressed into service as soon as they are old and strong enough to wield the pestle.

The pounded ore is screened until nothing is left in the mortar, the sieve comprising a native basket rather openly woven. The ore which has passed through the mesh is carried away for washing or panning to the river side. One woman, for the first washing, excavates a pit about 2 feet in depth and about 2 feet 6 inches in diameter. This is filled with water up to about one foot of the top. Standing in this pit, the woman, with the aid of a calabash tray some 18 inches in diameter, half fills the tray with ore. She then washes the contents in the water, imparting to the tray a rapid circular oscillating motion, thereby causing the contents of ore and water to follow a circular course within the tray. In this manner the lighter and finer matter is separated from the particles of iron and discarded by falling to the bottom of the pit, while the heavier particles remain in the tray. When the operation of washing is carried out sufficiently, the contents are dumped on one side for the second and final washing. This is carried out by another woman seated close by, the ore being placed in another tray and similarly treated in clear water, the sluicing and agitating being continued until the water drawn off is quite clear and free from coloring matter. This stage attained, the ore is considered ready for smelting, the tailings or residue of finer material being thrown away. The ore after this second washing is dumped into the kiln, as the occasion may require, in a damp state.

There are eleven smelting houses in the village—all exactly alike in every particular. The hut is of rough nonagonal plan and measures from 25 to 26 feet in length by about 16 feet in width, and is invariably placed east and west along the longer axis. At each end is a doorway. The walls of the structure are constructed of clay daub carried to a height of 4 or 6 feet from the ground level, and with a space left all round at the top for light and ventilation under the eaves of the roof. At intervals around the walls posts are imbedded in the clay walls for carrying the supports of the roof, while the ridge of the latter is further supported by two other posts placed within the hut and steadied by a rude tie-beam spanning the building from side to side of the eaves. The roof is carried up at a sharp angle to the top ridge and is thatched with palm leaves. Owing to the great height of the roofing ridge, which is about 25 feet above the floor level, the possibility of the structure catching fire from the flames from the cupola is very remote.

The most prominent feature of the smelting house is the cupola, which is of ingenious design and construction. It is placed in the center of the hut and is built entirely of clay. It occupies a circular space, the diameter of which varies from 7 feet to 7 feet 6 inches, and about 3 feet 9 inches in height from the floor level to the crown of the dome. The entrance to the cupola is on the eastern side and directly facing the doorway. The sill of the cupola is placed about a foot below the level of the floor and there is an irregularly-shaped depression in the floor about 4 feet in length by some 3 feet 6 inches wide, whereby access is obtained to the doorway and to the interior of the cupola. This entrance occupies about one-fourth of the total circumference of the cupola. Distributed around the remaining circumference of the cupola are seven rough counterforts, each slightly less than 12 inches each way in dimensions alternating with six openings through the walls of the cupola. Each opening is about 18 inches in height and tapering from 9 inches to 6 inches in width. The entrance to the cupola occupies, therefore, the width of one counterfort and two openings. The sides, top, and bottom of each opening slope inward and downward toward a point about the center of the base of the furnace. On the outside the dome of the cupola is rounded up slightly and measures from 3 feet 6 inches to 3 feet 9 inches across. In the center of the dome is a circular opening to act as a flue 9 inches in diameter. Slightly below the curve of the dome is a rope of twisted vines or creepers passed around the cone and pegged down into the clay for increasing structural stability, and preventing the walls from cracking and opening out, in the same manner as the iron band or strap is utilized in the cupolas of the ordinary steelworks.

The greatest diameter of the cupola is approximately 2 feet 6 inches, at a height corresponding to the outside floor level, and the floor of the furnace is about 2 feet lower. The total height of the furnace is approximately 5 feet, and the space is of an elongated egg-shape in section. The surface is smoothed down in clay. The larger end is at the base and the sides taper inward on easy curves toward the orifice or flue at the crown.

An aperture about 4 inches in diameter is provided in the center of the bottom of the cupola communicating with a short tunnel dug below the floor of the house, to which access is provided by means of a pit immediately inside the western entrance of the hut. On the northern side of this tunnel there is a branch tunnel passing out underneath the walls of the house and communicating with an open drain. This tunnel serves to carry off any moisture that might accumulate in the main tunnel during the wet season.

The other features of the smelting house are a small vertical oven 2 feet 6 inches in length by nearly 2 feet wide and 4 feet in height, inclosed on all sides and the top, except on one of the narrow sides. In this rudely-shaped appliance the native smelters fire the earthenware pipes they fashion for conveying the draft of air into the center of the fire when the cupola is in operation. These pipes are likewise of primitive fashioning, each being about 2 feet in length by 1½ inches internal diameter. The other fixture within the house is a bin 4 feet 8 inches long by 2 feet 8 inches across, with walls of clay 9 inches high, in which ore is stored. A notable feature of all these fittings, which are constructed of clay daub, is the dispensation of supports of any description, while the tunnels themselves are simply bored through the soil with no other support than that of its own strength, though it has to assist in the support of the weight of the cupola at the end where it enters the furnace. The interior of the smelting house is occupied by heaps of charcoal, calabashes—the native transport medium and measure—flux, metal, tools for operating the furnace, and other necessities.

The smelting process is both ingenious and interesting and displays the intelligence, ingenuity, and skill of the natives in their judgment and operation. Smelting occupies, on the average, about thirty-six hours. A cupola is charged shortly after sunrise on one day—about 5:30 in the morning—and drawn off shortly after sunset on the day following. Over night the smelters close the six vertical apertures in the cupola by inserting in each two of the earthenware pipes, one above the other, built around with charcoal and inclining downward toward the center of the bottom of the furnace, to which point all the pipes concentrate. The opening is then sealed with clay to a thickness of about a couple of inches, but the entrance to the furnace is not closed until the last moment. On the following morning, shortly after daylight, the actual charging of the cupola commences. The orifice in the bottom of the furnace communicating with the tunnel is first closed by the aid of a cone of damp sand forced upward into the orifice and calked tightly with the same material. Live charcoal is then placed in the center of the cupola and the firing commenced. Directly this is accomplished and the fire properly set going, the door of the cupola is closed by the fixing of three pairs of the earthenware pipes in a position corresponding to those already fixed in the six other apertures around the cupola. They are likewise packed around with charcoal and finally sealed up with clay.

By this means the inward flow of air is confined and the result is immediately shown by the flame brightening and the heat becoming more intense. The draft, it will be seen, is supplied to the fire through nine pairs of pipes, and their sectional area is approximately 1.54 inches. As there are eighteen pipes supplying the draft and the opening in the crown of the cupola is about 9 inches in diameter, the relationship between the inflowing current of air and the escape in the dome is roughly in the ratio of 3 to 7; i.e., the outlet is two and one-third times as great as the inlet. It will thus be seen that an efficient forced draft is insured in a simple but effectual manner.

Directly the fire is well established, a flux is thrown upon it though the flue in the dome of the cupola. This flux is obtained from the slag or clinker refuse from the previous smelting. This flux constitutes one of the most important features of the operation, since without it the smelters confess that they would be unable to carry out their industry. How or whence it was first obtained is wrapped in obscurity, since the headman of the village stated that as they moved from point to point they always carried some of their flux obtained at the immediately preceding smelting with them. They entertain no apprehensions as to exhausting their supplies of flux, since it increases as time goes on, because the yield of flux from each smelting is more than sufficient for the next operation. It is a noteworthy feature that the smelters always use the flux obtained from the last time the furnace is used and it is obtained immediately before the cupola is opened for drawing off the smelted metal. How it was first obtained the headman was unable to explain to Mr. Bellamy, but the latter advances the theory that it has been handed down from time immemorial and its discovery is evidently centuries old, and possibly explains how the earliest workers in iron were able to obtain their metal.

Two hours after the furnace has been started the first charge of flux, representing about five pounds in weight, mixed with some two bushels of charcoal, is thrown on the fire. Another two hours are allowed to elapse and then this flux is drawn off through the aperture in the bottom of the furnace communicating with a tunnel, and another similar charge of flux and charcoal added. Thus two charges of flux are given before actual smelting commences. Two hours later the second charge of flux is likewise drawn off, at the conclusion of which the fire is considered to have been sufficiently cleaned and is ready for the first charge of ore. Five pounds of flux are first thrown on the fire, then some two bushels of charcoal, and immediately afterward the same weight of ore as flux, namely, five pounds, in the washed and damp condition.

The cupola is fed no less than ten times in this manner from start to finish, but before each successive charge of ore is made the charge of flux in the previous operation is first drawn off as already described, and it is not until the ninth, tenth, and final charges of ore are made that the flux is considered of any utility for assisting in the next smelting. Thus the flux used is the residue of the eighth, ninth, and tenth charges. It will thus be readily observed that the supply of flux for a smelting operation easily exceeds requirements. With each draw-off, however, there is a considerable quantity of dross which is discarded and a certain amount of judgment is required on the part of the smelters to discriminate between what is serviceable flux and worthless dross, in which Mr. Bellamy

states that the natives exhibit commendable intelligence.

The quantity of ore supplied to the furnace is not always that of the first charge, which is about five pounds, but is gradually increased with each successive charge. According to the head smelter, the quantity is increased from the third of a calabash—the native primitive method of measurement—to a calabash and a half, which is between 25 and 30 pounds maximum charge, and which constitutes the eighth and subsequent charges, the last three charges thus being equal. The precise moment at which each successive charge should be made is purely a matter of judgment and experience, the head smelter explaining that the fire must be white hot before the operation can be carried out. It would seem, however, that the period between each charge ranges from two to three hours, while five hours are permitted to elapse between the last or tenth charge and the opening of the cupola.

Directly the time has arrived for drawing the furnace one of the smelters descends into the tunnel communicating with the furnace and opens the aperture thereto by means of a long wooden pricker, thereby allowing the flux to run off. The last of this flux is considered to be the best for the smelting process, and is immediately set on one side for the purpose, but the first part of this run-off, which may weigh some forty pounds, is set on one side for closer examination by daylight the following morning. The clay seals over the six apertures of the cupola are broken by means of a wooden ironshod crowbar, the earthenware pipes are withdrawn, and being useless for future use, are thrown away. The doorway is then opened and the charcoal raked out, drenched with water, and carried away in calabashes by boys. The smelted metal is then seen lying in the bottom of the furnace in the form of a solid mass or pig. This lump is dexterously maneuvered about until it is brought to a convenient spot and is then withdrawn by means of a loop of green creeper and similarly hauled out of the shed into the open air in its red-hot condition and there allowed to cool off until the following morning. It is then ready for breaking up into conveniently sized pieces for further working. In this raw state it is sold at the market, the smiths purchasing the metal carrying out their own puddling.

According to the head smelter, the total quantity of ore charged into the furnace during the whole operation aggregates 162½ pounds, in the following charges:

For the first charge, about.....	5	pounds.
For the second charge, about....	7½	pounds.
For the third charge, about.....	10	pounds.
For the fourth charge, about....	12½	pounds.
For the fifth charge, about.....	15	pounds.
For the sixth charge, about.....	17½	pounds.
For the seventh charge, about...	20	pounds.
For the eighth charge, about....	25	pounds.
For the ninth charge, about.....	25	pounds.
For the tenth charge, about.....	5	pounds.
Total	162½	pounds.

The weight of each pig as the yield of each operation, as near as could be estimated, was between 70 and 80 pounds. Taking the average yield at 75 pounds, the ratio of metal to crude ore is 75 to 162, which is equivalent to 46 per cent; i.e., out of every 100 pounds of ore charged into the cupola the natives obtain 46 pounds of metal. The remaining 54 per cent comes away in the form of clinkers, from which the necessary flux for the next smelting is selected and the residue thrown away.

Mr. Bellamy found the head smelter to be highly intelligent and freely communicative upon the details of the process, personally explaining the various stages of the operation. He furthermore stated that so far as he knew there were no other smelting works in the central countries of Africa, at least for a distance of several hundred miles around, and that he had never heard of any other existing. It is a noteworthy fact that the products of this village are known for a considerable area round, the markets at which the metal is disposed of in some instances being many hundred miles distant. The existence of this unique settlement may offer the solution to the problem that has frequently confronted explorers when traveling through the interior regions of the continent, and who have been sorely nonplussed as to how the uncivilized savages have become familiarized with iron, which they use for agricultural and other purposes.

The pig iron, after it has cooled down, is broken up into marketable pieces by women and children. For this work the woman uses a heavy, hard stone. Owing to the absence of standards of weight, a crude system is practised in the disposal of the metal at the markets, the metal being piled up in small heaps and exposed for sale; this heap for five cents, that for ten cents, and so on. The natives have very little idea of the market value of their metal, but the head smelter, when drawing off the yield at the furnace during Mr. Bellamy's visit, expressed it as being very good, and that it would fetch about two and a half dollars, which is equal to about $70 per ton.

During the return to the coast after the conclusion of the expedition, Mr. Bellamy visited a native smithy at Oyo, to follow the subsequent working of the metal into articles of commercial utility. Here, again, everything was of the most primitive description. The bellows comprised a pair of circular wooden bowls each about 12 inches in diameter, connected by an air passage made of wood, from which two wooden pipes do duty for the tue-iron lead to the hearth. An undressed goat skin was loosely stretched over each bowl, to which in the center was fastened a long bamboo rod, one end of which was held in each hand. By raising and lowering the rods alternately, a more or less continuous current of air was obtained. The bellows are without inlet valves, the air supply simply entering by the wooden tue-pipes, a space being left between the stone of the hearth and the nozzles for this purpose. The bellows, together with the hearth, rest upon the ground. For the heavy forging work a large, smooth, undressed, water-worn stone served as the anvil, but for the smaller and finer work an anvil similar to that used by the silversmith and fashioned out of native worked iron was utilized. The hammers at first sight resembled but crude lumps of iron attached to wooden handles, but upon closer inspection it was observed that they were ingeniously fashioned upon a systematic basis, diamond-wise in section, so that a flat or a straight plane could be presented simply by a turn of the wrist.

In puddling the pig iron the metal is placed in the fire and the bellowsman applies his bellows, gently at first, but with gradually accelerating speed as the metal increased in heat. In this work great skill and intelligence, born of long experience, was shown, and the smith worked the metal up in the manner desired by his visitors, shaping off one end while the other was left undressed.

In this workshop Mr. Bellamy found an English rose-head nail. When the smith was asked his opinion of the metal of which it was made he emphatically described it as "no good," and scornfully repudiated the suggestion that he might use such metal for his work. As a matter of fact, the natives express supreme contempt for any of the modern-produced metal, and state that it is absolutely useless for the tools which the natives use, as it lacks strength and durability, two important factors, in the natives' estimation. At another smithy several European implements were found, such as knives, pruning hooks, and other similar tools, in which a brisk trade is plied. But the natives one and all express the opinion that they are only gotten up for show and that the metal cannot compare with the native-produced material. In fact, there exists a strong prejudice against the modern foreign-produced metal, and it will be no doubt a very long time before the native product is ousted from the market.

In order to ascertain the nature of this native metal several samples of the ore, fluxes, and pig iron were submitted to analysis. From the results of these investigations it is shown that the ore is very siliceous hematite, containing only 36.67 per cent of metallic iron, mostly as peroxide. The roasting operation drives off the small quantity of combined water latent and the little ferrous oxide that exists is converted into ferric oxide. By grinding and washing, the siliceous residue is reduced from 43 to 14 per cent and the proportion of metallic iron increased from 36.67 to 60 per cent. The fluxes used are ferrous silicates to any ordinary tap cinder, only they are more siliceous and contain less iron. The clinker employed as a flux is the last which is drawn off before the cupola is opened and is lower in silica and contains about the same percentage of iron as the clinker afterward selected.

The analysis of the smelted metal has shown that it is pig iron which has been partially decarburized by the oxidizing flux, and is really puddled steel low in sulphur and phosphorus, hence its good quality. The process of puddling by the smith prior to forging evidently continues the refining, as the metal is held in the blast until sufficiently decarburized. This puddling reduces the silicon, which is 0.252 per cent in the raw pig, down to 0.026 per cent, and reduces the carbon from 1.6 to 1 per cent, decarburization evidently being carried to a degree varying with the purpose for which the steel is to be used. From a metallurgical point of view the process, though essentially crude, is similar to most direct processes, the metal being reduced by charcoal, then partially decarburized in the same furnace by the aid of the fusible oxides, which also serves to remove the phosphorus. This dephosphorizing is carried out very completely, since, whereas the washed ore contains 0.033 per cent, it is reduced to 0.01 per cent in the steel, while if smelted in the modern blast furnace the phosphorus would be reduced to 0.06 per cent.

According to Mr. F. W. Harbord, F.I.C., who carried out the analyses for Mr. Bellamy, it is probable that the metal never collects in a fluid state on the bottom of the furnace, but as it is reduced and falls through the bath of oxidizing flux it is partially decarburized, its melting point raised, and the temperature just high enough to enable it to gather together in the form of a metallic sponge, from which the fluid slag can be tapped off from time to time. It, however, comes somewhat as a rude shock to steel workers who pride themselves upon the production of a high-grade steel as a comparatively recent discovery, to learn that it is in reality a very ancient process practised by unsophisticated savages centuries ago.

Although, according to Mr. Bellamy, these native smelters follow habits of life which, according to our standard of civilization, would be described as savage, yet the very fact that they have for ages been engaged in such an important and unique industry places them entirely above such a level. They lead, it is true, a simple and unsophisticated life, but owing to their calling they are far above the ordinary savage in the social scale. They possess remarkable intelligence and skill and are most enterprising in their unusual vocation. Unlike the average Ethiopian they carry out their work methodically and quietly, without the slightest bustle or confusion. From sunrise to sunset they follow their work with commendable zeal and enterprise. The men, women, and children participate in the occupation, the children adopting the calling as soon as they can run about. The boys are employed in the usual transport and apprentice duties, being inculcated in the more skillful tasks as they approach maturity and gain proficiency. Each cupola is run on the share system under a separate section of the village. There is no scheme of community of interests. None are too old to work and none too young, either male or female, to learn and assist, so that the village is indeed a busy, industrious, and enterprising settlement.

PLATINUM PLATING AND ITS EXECUTION.

THE deposition of platinum has always been one of the conundrums of electroplating. Some of the early treatises on plating give methods for its execution and say that it can be successfully accomplished. Others say that it cannot be commercially done. Various formulas have been given, but of late years little seems to have been done upon the subject.

The fact that the platinum anode that is used for platinum plating will not dissolve seems to frighten many platers. They believe that this fact precludes the use of platinum plating. It must not be forgotten that some of the most successful gold platers use platinum anodes at even a greater cost than gold. The insolubility of the platinum anode does not affect the deposition of platinum in the least and may, perhaps, actually be in its favor as the quantity of platinum that is deposited may be regulated better. In other words, as the solution keeps getting weaker and weaker, the platinum deposits more slowly. If the anode were not insoluble, it would be liable to overload the bath and more platinum would be deposited than intended. This is the argument put forth for the use of a platinum anode in a gold solution. The gold deposit is sure never to exceed the primary amount of gold determined upon for a given time of deposit. If the solution becomes stronger, as it might do with a gold anode, the deposit for a given length of time might be heavier than intended. These arguments are neither here nor there, however, and are open for further discussion.

The statements in regard to platinum plating were so contradictory that we thought it advisable to make some experiments upon the matter. We are pleased to say that the difficulties of depositing platinum are not so great and are as easily accomplished as gold plating.

Some platinum was dissolved in aqua-regia and evaporated to a syrup. This was used for making the experiments. Some of the platinum baths recommended in old treatises on electroplating were tried.

The bath made by dissolving chloride of platinum made from one ounce of metallic platinum in one gallon of water and then adding forty ounces of carbonate of soda crystals, was not found very satisfactory. The bath was used nearly boiling, as all platinum baths require heating in order to obtain a bright deposit. Although an excellent deposit was obtained on brass, copper, and German silver, the bath rapidly decomposed upon standing and metallic platinum separated out. In a few hours the bath became dark brown, although previously clear. In twenty-four hours, the bath was nearly black from separated platinum. The separation of the platinum militated against its use as, in order to employ it successfully, the bath would have to be freshly made every time it was used.

Another formula which contained caustic soda instead of carbonate of soda was found to be open to the same objection. The platinum separated out of the bath spontaneously upon standing. This fact precluded its use. A good, bright deposit was obtained from it, however. Many of the other solutions were found open to the same objection.

The most successful and satisfactory solution for depositing platinum is the double phosphate bath. This bath is recommended by Roseleur. He was undoubtedly its discoverer. We can recommend it highly and have been able to obtain some excellent examples of platinum plating by its use. As far as we have been able to investigate, this bath is the most satisfactory. We herewith give the method of making the bath. We have modified Roseleur's process a little. He recommends the use of phosphate of ammonia. This material is unstable and is difficult for many platers to obtain. We have arrived at the same results by adding phosphoric acid to the solution and then ammonia. The ultimate effect is the same as though phosphate of ammonia had been added. To make the solution take the following:

Dissolve 1 ounce (or 30 grammes) of platinum in a mixture of 15 ounces of strong muriatic acid (or 450 cubic centimeters) and 10 ounces (or 300 cubic centimeters) of strong nitric acid. When the platinum is dissolved, evaporate at a gentle heat until the mass is syrupy in the bottom of the dish. A porcelain dish should be used for this purpose. When cool, this chloride of platinum is dissolved in 3 quarts of water (or 3 liters).

To the solution is now added 15 ounces (or 450 cubic centimeters) of 50 per cent phosphoric acid and ammonia is added until the solution smells strongly of it. This will produce a yellow precipitate of phosphate of ammonia and platinum. It should not be filtered out but allowed to remain in the solution. The solution should turn red litmus paper blue.

The next step is to dissolve 50 ounces of phosphate of soda (1,500 grammes) in 3 quarts of hot water (or 3 liters). The solution is now heated nearly to boiling and the yellow precipitate will gradually dissolve. The heating must be continued until all the ammonia

is driven off so that it no longer smells of it and red litmus paper is turned slightly blue. This usually takes several hours and the water which evaporates must be replaced. When finished the volume of the solution should be about 1½ gallons (or 6 liters).

The solution is now ready for use. It must be used hot, nearly to the boiling point, and a platinum anode used with it. The current that is used must be strong and from five to six volts are required to coat the article. At a low voltage the deposition will not take place. The deposit does not adhere to steel or iron and the article to be plated should be of copper, brass, or German silver. It is likewise useless to run the article through a "quick" dip as mercury and platinum will not amalgamate. The article must be well cleaned as the solution is slightly acid and has no grease dissolving powers.

The deposit forms immediately and with a slight, gray film on the surface. In a minute a sufficiently heavy deposit for most purposes is produced. For flash deposits a few seconds are all that are required.

The deposit is hard and does not burnish well. Neither do brass scratch brushes work well upon it. They leave a yellow color on the surface. Fine steel scratch brushes must be used. They are, however, usually unnecessary as the work only requires a very light buffing to bring out the color.

The color of the platinum is white, although not as white as silver. It is a little whiter than nickel. For ornamental deposits it probably will not be of value as its color is too near that of nickel. For plating surgical instruments, scientific instruments, spark plugs for gas or gasoline engines, and many other uses it will be found very serviceable. Steel should be nickeled before depositing the platinum.

Roseleur mentions that he patented this solution in 1847 and plated many articles with it. He presented to King Louis Philippe of France a platinum plated basin, the first piece of platinum plated apparatus ever made. He also states that a copper dish which he plated resisted the action of strong nitric and strong sulphuric acids for twenty evaporations without being sensibly attacked, but the last time the deposit began to show indications of having been attacked.—Brass World.

HOT-AIR BALLOONING.

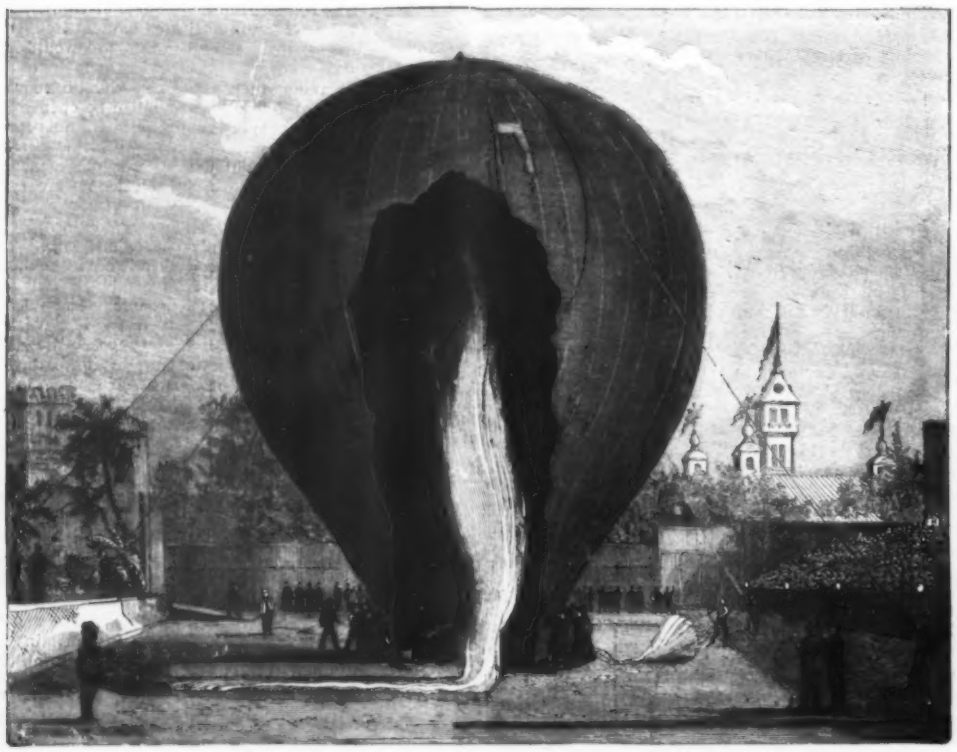
A HOT-AIR balloon is made of sheeting. This is one yard wide, and in the balloon which we illustrate forty segments of it were required for the circumference. For 16 feet from its top each segment was tapered nearly to a point. The next 15 feet were untouched, and then the last 29 feet leading to the neck of the balloon were also tapered to about one-fourth their width. The segments were sewn together, as in making a regular seam; a cord was then laid alongside the seam, and the double edges bent over and resewed, making a sort of felling. The top was made of double thickness. The sheeting was sized with a mixture of glue, alum, soda, salt, and whiting, in water.

At the mouth of the balloon a hoop 8 feet in diameter made of buggy-wheel felloes is attached; from this hoop four ropes, called quarter guys, are brought down, to which the parachute is attached.

THE CUTTING LOOSE BLOCK.

ascent. The construction of the balloon with cords felled into it is such that no net is required. As the aeronaut goes up clinging to the hoop of the parachute, it is necessary that he should have some means of detaching himself, at will, from the balloon. This is afforded by the arrangement shown in one of the small cuts. To the quarter guys of the balloon is attached a block of wood by means of a rope passing through a hole in it. Above this hole a knife-blade is pivoted, which works in a slot in the block, and held out of contact with the rope by a rubber band. To the end of this blade a rope is attached leading down to the aeronaut's hand. By a second rope the parachute hangs from the same block. It is obvious that on pulling the cutting line the rope will be severed and the parachute detached. One more appendage remains to be noticed. Within the parachute, near its mouth, a wooden hoop 4 feet in diameter is suspended, and by a proper system of guys is held in a horizontal position. The object of this is to insure the opening of the canvas.

The inflation is thus conducted: A trench about 18 feet long, 2 feet deep, and 2 feet wide is dug in the earth where the balloon is to be inflated, and, except a small portion at each end, is covered with iron, boards, and earth. Over one end an iron cylinder 3 feet high and about 3½ feet in diameter is erected. Around this cylinder barrel staves are placed with earth between them and the iron, forming a sort of rough lagging. On each side of the chimney thus provided, and at a good distance therefrom, two poles 28 feet high are erected; each carries a pulley, and a rope is rove through the pulleys and carried through a ring on the top of the balloon. The mouth of the balloon is placed over the chimney, and, by means of the rope, the top is hoisted well up from the ground.



COMMENCING TO INFLATE THE BALLOON.

The parachute in general structure represents the cover of an immense umbrella. When expanded it is about 28 feet in diameter. It is made in gores, and in its center has a 12-inch hole. From its periphery thirty-two cords lead down to what is known as the concentrating hoop, a strong wooden ring 18 inches in diameter, which the aeronaut grasps in making his

A wood fire is started in the distant entrance of the trench; this gradually heats the trench and smoke-stack, the draft at first being about as much one way as the other. After a few minutes, however, the draft begins to tend strongly toward the chimney, which is encircled by the mouth of the balloon, the sides being held well out from the center by a corps of assistants. From time to time a little kerosene is thrown on the fire. All this while an attendant stands within the balloon, by the side of the chimney, armed with a circular board to act as fire screen, and with a pail of water and a cup near him to throw water upon the cloth should it become ignited. The balloon gradually feels the buoyant effect of the heated products of combustion, and as it tends to rise, more and more cloth is fed out, the assistants shifting their hold lower down upon the sides of the balloon. After ten or fifteen minutes the suspending rope is cast off and pulled away from the balloon, and four guy ropes leading from its top are used to keep it in position. It swells continually, and the canvas rises until only the hoop rests upon the ground. A number of the assistants now stand upon this hoop.

The last heating remains to be done. At short intervals kerosene is thrown upon the fire, by this time largely consisting of a mass of very hot embers. The oil is at once volatilized and rushes as a gas into the balloon, within which it suddenly bursts into ignition, producing a great sheet of flame, plainly distinguishable through the cloth. This is repeated over and over again, each addition of kerosene producing a great flame as it ignites, almost with explosive violence, within the expanded canvas, now straining violently upward.

The upper end of the parachute during the inflation has been attached to the balloon, and the aeronaut stands to one side, as the balloon is nearly ready, grasping the concentrating ring. When all is prepared, the word is given, and the balloon is released. The chimney is covered, and, as the balloon rises, the aeronaut walks or runs forward under it, and is carried up clinging to the parachute ring. A loop of rope is attached to the ring, and, when some distance up, he steps into this loop and thrusts his head up through the concentrating hoop, so as to leave his hands free to manipulate the cutting rope. When a sufficient height has been attained, and he deems himself over a favorable ground for a descent, he pulls the cutting rope and severs the connection between himself and the balloon. He commences to drop with accelerating velocity until the air, catching the parachute, suddenly opens it just as an umbrella is opened by hand. The velocity of the descent is checked. With some oscillation the earth is approached quite rapidly; in half a minute or less the surface is reached. The object of the aperture in the center of the parachute is to make these oscillations as slight as possible. The earth is struck with some violence, about as if the jump was from six or eight feet elevation, indicating a velocity of about twenty feet per second. The deserted balloon capsizes, owing to the greater weight of its top, the hot air and products of combustion with considerable smoke escape, and it collapses and rapidly falls.

As the ascent is made, the entire distance from the top of the balloon to the aeronaut hanging to the parachute is about 175 feet; the inflated balloon is about 40 feet in diameter.

Accidents in the descent are often to be anticipated; sometimes the parachute falls among trees, from whose branches the operator drops to the ground, the parachute losing its effect the moment that his fall is checked.

The cubic capacity of the balloon is about 28,000 cubic feet. Its lifting power is greater than would be the case with a similar gas balloon, on account of its extreme lightness. The absence of net and car and of heavy varnish conduces to its power.

EFFECT OF MOISTURE ON THE STRENGTH AND STIFFNESS OF WOOD.

VERY little is definitely known about the influence of moisture on the strength of wood, even by those experienced in handling the material. Since the whole subject is one of great importance, the Forest Service has been making a thorough study of it during the past three years and is about to publish the results of its investigation in an exhaustive technical bulletin entitled, "Effect of Moisture Upon the Strength and Stiffness of Wood."

The chief points presented by the study are:

1. The relation of moisture to strength follows a definite law which can be graphically expressed. Proper drying very greatly increases the strength of all kinds of wood, the amount of increase in strength depending upon the species and the dryness. The increased strength given to green wood by thoroughly drying it is so great that it will surprise many. For example, the strength of a piece of unseasoned red spruce may be increased over 400 per cent by a thorough drying at the temperature of boiling water. Strength decreases again, however, as the wood reabsorbs moisture. Air-dried wood, protected from the weather, and containing 12 per cent of moisture, is from 1.7 to 2.4 times stronger than when green, varying with the species. Stiffness is also increased by drying. These conclusions, however, are drawn from small-sized pieces not exceeding 4 by 4 inches in cross-section such as are used in vehicle work, tools, etc. Large timbers require years of drying before the moisture is reduced to the point where strength begins to increase. It must also be taken into consideration that more or less checking always occurs when large timbers dry; and if this checking is excessive it may cause weakness to counterbalance, partially or entirely, the strength gained in drying. Consequently it is not safe to assume that the average strength of large so-called seasoned timbers is much greater than that of green or wet ones.

2. The fiber saturation point of a number of species

has been determined. This point, which varies with conditions and species of wood, designates the percentage of water which will saturate the fibers of the wood. It has been found that, under normal conditions, wood fiber will absorb a definite amount of moisture; beyond this the water simply fills the pores of the wood like honey in honey-comb. Only that water which permeates the wood fiber has an influence upon the strength. For the following species, the saturation point occurs at the given percentage of moisture based on the dry weight of the wood:

Longleaf pine	25	per cent moisture
Red spruce	31	" " "
Chestnut	25	" " "
Loblolly pine sapwood	24	" " "
Red gum	25	" " "
Red fir	23	" " "
White ash	20.5	" " "
Norway pine	30	" " "
Western tamarack	30	" " "

3. Prolonged soaking in cold water does not reduce the strength of green wood below that of its fiber saturation point, provided it remains in perfect condition. When wood has been dried and is resoaked, it becomes slightly weaker than when green.

4. Wood soaked in heated water absorbs more moisture because the amount of water which the fiber will contain is increased. This causes a reduction in strength and stiffness, as in wood that is heated or steamed for bending.

AN ELECTRIC RECORDING PYROMETER.

IN this era of rapid technical progress, in all industrial and manufacturing establishments where high temperatures are employed there is an increasing demand for instruments to automatically and accurately record every change that occurs. Records obtained from such apparatus make it possible to control the temperatures, so that the product is perfectly uniform and most economically produced.

The recording pyrometer, illustrated in the accompanying illustrations, has been designed by Mr. William H. Bristol, and is of the thermo-electric type, which is capable of application to numerous commercial and industrial requirements.

A complete instrument consists of the following parts:

1. The recorder, which is located at the point most convenient for observation of the records and for changing of the charts.

2. The thermo-electric couple, the fire end of which is to be inserted into the space where the temperature is to be measured.

3. The leads, consisting of duplex flexible cable, for making the electric connection between the recorder and the fire ends.

The details of the pyrometer proper were shown in SCIENTIFIC AMERICAN SUPPLEMENT No. 1585.

The current of electricity produced by the thermo-electric couple, which is located where the temperature is to be measured, is communicated to the recorder through the connecting leads, and actuates a galvanometer movement which is contained in the dust-proof metal case shown at the upper portion of Fig. 2. The galvanometer movement is made according to a special design by the Weston Electrical Instrument Company, with pivot and jewel bearings for the moving coil. It is "dead beat" in its action.

The delicate recorder arm moves perfectly free and clear just in front of a chart which is revolved by a clock movement once in twenty-four hours or at any other desired rate.

The chart, consisting of a circular sheet of paper, is coated with a semi-transparent smoked surface, which is so sensitive that a record may be made upon it with a hair. The prepared paper is applied to the instrument by being placed upon or over a semicircular plate, shown in Fig. 2, so that the plate will support the paper, while the other half of the sheet is supported and is free to vibrate. The paper is fastened or clamped in the center to a revolving shaft and is free to revolve over the semicircular plate. The latter is located at the lower part of the illustration. The clock movement for revolving the chart is contained in the round case behind the semicircular chart support, and is provided with an auxiliary attachment for periodically vibrating the unsupported portion of the chart, thus bringing its smoked surface at intervals of a few seconds into contact with the pointed end of the recorder arm. Each impulse given to the paper causes a dot of the carbon film, in rubbing against the point, to be removed. By this means the record of its position is obtained, and friction is absolutely eliminated.

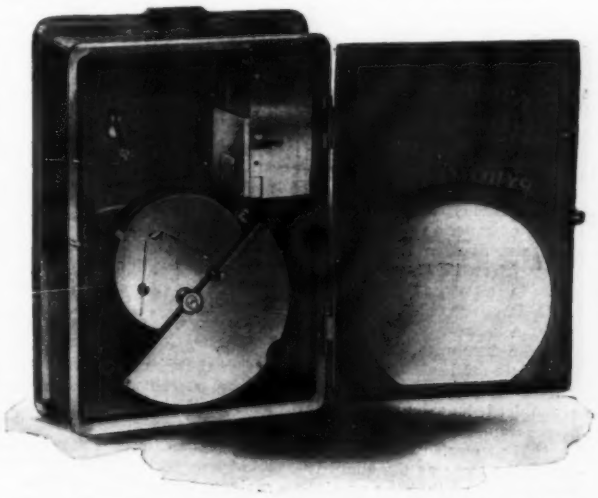


FIG. 2.—SEMICIRCULAR CHART-SUPPORTING PLATE.

The series of marks made by the periodic contact of the recorder arm where the carbon is removed from the chart forms a continuous curve, unless the changes of temperatures are extremely rapid.

FIG. 1.—BRISTOL'S FRICTIONLESS RECORDING PYROMETER.

After the record of the day is completed the chart is removed from the instrument, and "fixed" by immersion in a fixative solution. This solution consists of gasoline or alcohol to which has been added a small amount of concentrated fixative. After fixing, the charts may be handled and filed away without danger of destroying the record.

Fig. 3 is a reduced photographic reproduction of a smoked chart, with a record of the temperature in a lead bath which is used for calibrating these pyrometers. It is interesting to note the constancy of the temperature during the period of nearly half an hour, while at night the mass of metal was cooling and passing from the molten to the solid state.

The simplicity of construction insures durability and permanent accuracy, and makes the operation of the instrument an easy matter. The protecting case containing the galvanometer is hinged to the back of the recorder, and in Fig. 2 is shown turned to one side. This arrangement provides against danger of injury to the recorder arm while charts are being changed and the clock wound.

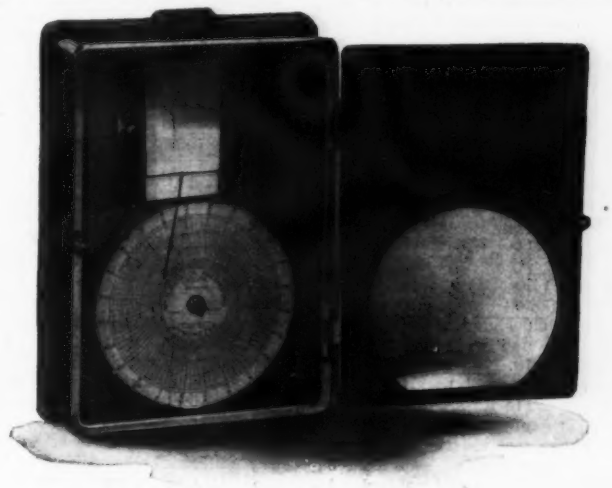


FIG. 3.—APPEARANCE OF SMOKED CHART AFTER A RECORD HAS BEEN MADE.

The charts as mentioned are prepared with a smoked surface, the special feature being that the coating of lamp black is not sufficient to obscure the graduations, and that the edges and center are unsmoked. The unsmoked portions permit the charts to be specially packed for convenient handling and shipment.

The couples employed for ranges not exceeding 2,000 deg. Fahr. are made of special alloys, which are inexpensive and may be of almost any desired form or length to suit the special requirements.

For ranges above 2,000 deg. Fahr. the standard Le Chatelier platinum and rhodium elements are used. The novelty of the recorder is in doing away with all friction and the use of ink, allowing the slightest movement of the machine to be recorded.

UTILIZATION OF WASTE MATERIALS.—I.

By DR. THEODOR KOLLER.

WOOD WASTE.

WITH regard to the utilization of wood waste two points have to be kept in mind. One of them is purely technical, viz., the manufacture of more or less valuable products out of scanty and apparently useless waste; the other belongs to the province of political economy, which requires that nothing should be lost, but that waste matter should be worked up into new forms and be introduced into the circulation of production.

The attempt to utilize wood waste arose perhaps from necessity, as in the case of the slag from blast furnaces, which by reason of its immense accumulation so greatly encroached upon the space available for work, that its removal became a problem involving the very existence of the furnaces.

The utilization of wood waste presents no technical difficulty. The only obstacle arises from the circumstance that the supply of wood waste is a local matter, so that its utilization is naturally, so to speak, "bound to the soil." When the waste matter has to be removed to great distances, its transformation into new products is quite unprofitable.

In places where wood waste is produced in large and, which is a very important matter, regular quantities, its utilization is very profitable, particularly when, in the preparation of specialties, products are formed in which other valuable properties are artificially added to the natural properties of the wood. As a result of a long experience, I maintain that valuable imitations and finished substitutes can be made only by employing the less valuable waste of the original substance. The only practical way of making imitations of and substitutes for leather and wood is properly to utilize leather and wood refuse. This should constantly be kept in view by manufacturers of imitations and substitutes. Much disappointment would then be avoided in this line of work, and we should have fewer specifications of patents to read which it can at once be seen are useless.

Wood waste can be used for a variety of purposes. It would be a mistake, however, to suppose that the various methods of utilizing the waste are all equally good. This is not the case either as regards the processes themselves or the profit derived from them.

With regard to the apparatus necessary for the process of utilizing wood waste, it is difficult to give directions which would be accurate and at the same time applicable to every case, as the methods of working and the purposes of the utilization vary considerably. Speaking generally, mixing and kneading machines, molds, and presses may be regarded as the essential apparatus, as in the manufacture of plastic masses.

A person seriously contemplating the preparation of products of wood waste should first be sure about several points. The first question must always be:

Is there a certainty of a sufficient, regular, and continuous supply of suitable waste? If this question has been satisfactorily answered, then a second question arises: Is my present or my main plant so fitted up as to offer special facilities for the manufacture of these products? This is important, for it bears directly on the question of the possibility of profit. The last question to be answered is the following: Does the article which I wish to make meet a real demand? and, Are the time and circumstances such that, after carefully considering all the conditions and recalling the results of my own experience and the experience of others, I may feel warranted in anticipating a brisk and steady sale of the product?

These questions must first be weighed and answered. The more thoroughly and dispassionately they are gone into and the more precisely they are answered, the more solid will be the basis for manufacture and the better the prospect of a successful outcome of the enterprise.

As regards the answers to the first two questions no assistance can be given, as they are personal and local in their nature. In considering the last question, however, some hints are offered which may help to put the matter in a clearer light.

The chief wood refuse, which must be kept prominently in view both in respect to its quantity and the frequency of its supply, is sawdust. The employment of the latter appears to have received considerable development in these days. The simplest and most obvious way to dispose of it is to use it as fuel. Attempts were made to do this at an early date, but they failed owing to the lack of suitable arrangements for its combustion. This difficulty has now been completely removed by the construction of proper stoves and ranges, and we now possess an excellent system of stoves and furnaces permitting of the satisfactory combustion of substances in the form of dust or powder.

Efforts were next directed toward preparing artificial wood out of sawdust, and here we enter upon the domain of actual manufacture. Glue-water and water-glass, also rosin, blood, and glue with potassium bichromate are used as binding agents for the sawdust. The most reliable binding agent is glue to which potassium bichromate is added to make the compound water-tight, insoluble chrome-glue being formed if the substance is exposed to light. The glue solution is made up of 5 parts good pale glue and 1 part of isinglass. This mixture should be soaked, slowly heated in water, and carefully filtered. The quantity of water depends on the quality of the glue; it should not be too small, but so much that the liquid is not transformed into a jelly-like mass when cool, but is just on the point of coagulating. The sawdust is worked into a mass with the glue solution. With regard to the molding, in addition to metal molds those made of gypsum or sulphur previously well oiled are employed; even wooden molds may be used if they have been previously well varnished with a solution of shellac in spirits of wine. The masses may first be applied several lines thick and well molded in by pressing with the fingers; then the remainder should be filled up with a mass prepared from coarser grains, and the surface covered and weighed down with a large plate. Before removing the mass, which is easily done when it is tolerably dry and has become compressed in consequence, any superfluous portions must be cut away with a broad and thin knife, so as to level the lower surface of the relief. The articles can then be varnished or gilded, in fact treated just like ornaments cut out of wood.

Wood paste, the preparation of which has been indicated by Kletzinsky, is well worthy of notice.

One hundred and sixty parts by weight of sawdust, preferably from soft varieties of wood, are well boiled in a solution of 100 parts by weight of aluminium sulphate in the requisite quantity of water and left to cool. Then 50 parts of glue are dissolved in 100 parts of water at boiling heat, and the solution thoroughly mixed with the sawdust pulp. The mass is then kneaded, rolled in pressing mats, and subjected to vigorous pressure. The pressed masses are very brittle at first, but acquire an extraordinary degree of hardness when allowed gradually to dry in the air. As soon as they are sufficiently hard they are moistened from three to five times with a five per cent solution of potash in water and finally dried. In this way the particles of wood are cemented together with a kind of alumed glue, which is no longer soluble in water and makes the mass as hard as horn. It stands to reason that any kind of coloring matter or even crude colored sawdust can be added to the alumina stain in order to obtain colored wood paste. Colored mosaic slabs for parqueted floors can also be made by mixing sawdust of different colors.

The fact that sawdust is a bad conductor of heat must of course be taken into consideration. On account of this property it has been recommended, and is frequently used, as a lining for ice-chests. There is no doubt, however, that when used for this purpose its action has not proved perfectly satisfactory; moreover, its regular supply is dependent upon local conditions, and it is by no means the best non-conducting substance.

Sawdust is also used for burning black clay pipes. A layer of sawdust and a layer of pipes, 300 to 500 pipes according to size, are placed in a large muffle; the muffle is then stopped up with cement and put into a furnace, and the latter closed by masonry as far as the fire-door. In the course of 10 to 12 hours the sawdust becomes carbonized under the action of the glowing heat, and at the same time colors the pipes black. The pipes, in sets of 20 to 50, are then placed on a round disk provided with the same number of pins, held over the smoke from burning straw, colored to an intense black, and polished with wax and a stiff brush.

Among other uses to which wood waste, and especially sawdust, can be applied, we may mention the preparation of oxalic acid. The essential thing, however, is to obtain a product adapted for manufacturing purposes, and for this not only adequate technical and chemical knowledge, but also suitable contrivances are necessary. It seems advisable therefore only to utilize sawdust for this purpose when the existing fittings are adapted for it. There need be no misgivings as to the disposal of oxalic acid and its salts, in view of the numerous uses to which they are applied.

The operation commences with the preparation of the lyes. Potash and soda are mixed in such quantities that after the causticizing of the lyes, the proportion of caustic potash to caustic soda is as 40 to 60. The two salts when mixed are dissolved in about eight times the quantity of water, and causticized by boiling in an iron pan with slaked lime. As soon as the carbonate of lime formed by this process has been deposited, the lye is allowed to flow into another iron pan and evaporated to the specific weight of 1.3 to 1.4. The sawdust must be freed from larger pieces of wood by passing it through a sieve and mixing with the caustic lye, using one part by weight of sawdust to two of the alkali. As it is essential that the entire mass of wood should be uniformly saturated with the lye, the latter is so concentrated that when mixed with the sawdust it is completely absorbed by it. The mass is then put into the vessels in which it is heated.

As the output of oxalic acid is most copious when the mass is spread in thin layers, it is advisable to use very flat dishes, about two meters in diameter and provided with edges five centimeters in height, for the heating process. The mass should be spread in these dishes to a height of one to two centimeters and constantly turned over by means of a mechanical stirrer in such a way that at every turn of the stirrer the mass is raised from the dish and allowed to fall on to it again.

As it is of the greatest importance to bring the temperature of the whole mass up to 240 deg. C. and not to allow it to rise above this point, it is advisable to heat the pans by means of hot gases escaping from a furnace, and not to place them over a fire. This can be done by heating a furnace connected by conduits with a lower space, the cover of which is formed by the pans. A carefully constructed sliding register should be inserted in every conduit for regulating the supply of gas or shutting it off when desired. With this contrivance it is not difficult to keep the temperature of the masses between the required limits. After the sawdust has been saturated with the lye it is put into the pans by means of flat shovels and spread out, the stirrer is put into operation, and at the same time the pan heated by opening the sliding register. Only water evaporates at first, and the mass grows darker till it reaches a deep brown color, a peculiar smell arising at the same time; when the temperature reaches about 180 deg. C., the mass begins to grow brighter till it attains a greenish yellow color. The temperature is now gradually raised to 240 deg. C., and kept at this point till a sample taken from the mass shows no trace of wood. The molten mass is now taken out with flat shovels and allowed to cool or, which is more advisable, worked up while hot.

In the latter case the molten mass is thrown into a boiler containing warm water, the hot mass dissolves quickly and heats the liquid to nearly boiling point; heat is added till the solution has acquired the concentration of 38 deg. B., and the latter then allowed to run off into flat crystallizing pans, in which the greater part of the oxalate of soda is precipitated with rapid cooling, a very little of this slightly soluble salt, together with carbonate of potash, caustic potash, and soda and some vegetable substances remaining dissolved in the liquid.

To free the oxalate of soda crystals from the mother lye they are put into a tall vat provided with a so-called false bottom; the mother lye is then allowed to drain off, and any of it still remaining washed away with cold water. The mother lyes are evaporated till dry, the residue freed from vegetable matter by roasting in the air, and the remaining compound of carbonate of potash and soda again causticized.

In order to bring the soda combined with the oxalic acid back again into the form of caustic soda, so as to make it available for the treatment of new masses of wood, the oxalate of soda is subjected to the following treatment: It is dissolved in a very little boiling water in a vessel heated by steam, the solution kept in constant motion by means of a stirrer, and thin lime-milk introduced into it till the decomposition is complete, i. e., till insoluble oxalate of lime and soluble caustic soda have formed.

The quantity of lime required is calculated from the quantity of oxalate of soda employed; as, however, neither preparation is entirely pure, the estimated quantity of lime is not always the same as the quantity really used. It is, however, important that the precipitate should not contain any excess of lime, otherwise a larger amount of sulphuric acid would have to be used in a subsequent operation than is requisite for decomposing the oxalate of lime. The precaution should therefore be taken to make repeated tests after the greater portion of the lime has been added, the samples being filtered, acidified, and mixed with a calcium-chloride solution; as long as the latter produces a cloudy discoloration in the liquid, there is still some undecomposed oxalate of soda present.

The milky liquid is then allowed to run from the decomposing vat into another vessel and remain there for a time, after which the clear soda lye is removed from the precipitate. The latter is then washed several times with water, and the first washing water, which still contains plenty of caustic soda in solution, added to the lye, but the succeeding water is used for dissolving fresh quantities of crude melted wood. The oxalate of lime, when sufficiently washed, is put into a tub lined with lead, stirred up into a paste with water, and then again stirred with the previously calculated quantity of sulphuric acid, diluted to 15 to 20 deg. B. The quantity of sulphuric acid is estimated according to the quantity of lime employed for decomposing; if two parts of sulphuric acid are taken to one part of lime, the quantity of sulphuric acid is in excess of that of the lime, and we get a solution of oxalic acid containing free sulphuric acid. It is nevertheless advisable to conduct the process in this manner, since the excess of acid aids the decomposition of the oxalate of soda, and the sulphuric acid may again be used in subsequent operations.

To accelerate the decomposition of the oxalate of soda, a continuous current of steam is made to flow through a thin lead pipe reaching to the bottom of the decomposing vessel; the steam holds the solid substances in the liquid in suspension, and also hastens the decomposition by the added heat. When all the sulphuric acid has been added, the liquid is allowed to stand for a time; then when the gypsum has settled, the oxalic acid solution is removed, and the gypsum washed with water on a piece of linen spread over a lead funnel. The first washing water is added to the oxalic-acid solution, the remainder being employed instead of pure water for washing the oxalate of lime in a new decomposing process. The gypsum remaining constitutes an excellent manure for clover fields; being very pure, it can also be drained or dehydrated and used as stucco gypsum.

The oxalic-acid solution is concentrated either by placing it in a flat leaden pan standing on a sandbath heated over a fire, or, which is more advisable, heated by steam till it indicates 15 deg. B. in summer, 10 deg. B. in winter. It is then cooled to the ordinary temperature, the gypsum dissolved in it being deposited in the form of crystals. The liquid separated from the gypsum is further evaporated to 30 deg. B. and put into flat leaden vessels for crystallizing.

The mother lye which is separated from the crystals contains, in addition to oxalic acid, an excess of sulphuric acid; the quantity of sulphuric acid is determined, and the lye again added in the next decomposition of oxalate of soda, the amount of sulphuric acid then used being of course correspondingly diminished.

The oxalic-acid crystals are rinsed with cold water to remove the mother lye adhering to them, and then purified by dissolving them in boiling water and allowing the solution to cool quickly, so that only small crystals are formed. The preparation thus obtained is pure enough for technical purposes, containing in addition to a very small quantity of sulphuric acid only some very slight traces of oxalates of soda or potash.

Artificial vanilline may also be regarded as in a certain sense a product of wood waste. Some years ago Dr. Th. Hartig discovered in the cambial sap of coniferous trees a substance capable of being exhibited in a crystalline form, to which he first gave the name laricine, but which he afterward, finding the same substance in most coniferous trees, called coniferine. It is prepared as follows:

Firs, larches, pines, etc., cut down between the middle of May and the middle of July, are gradually stripped of their layers of bark and bast and the young sappy wood fibers scraped with pieces of glass from the layers of already hard wood underneath and collected in vessels placed below. The scraped-off matter is then deprived of its sap by means of fine pressing cloths, and the sap immediately boiled. The coagulating glairy matter, together with the solid substances of the pressed sap (cell cores and starch) remains on a filter of blotting paper, and a clear filtrate is obtained which, when carefully evaporated to about one-sixth of its original volume, deposits the cambial sugar as well as the coniferine in a crystalline form. When treated with cold water, the slightly soluble coniferine can be separated from the sugar, and appears as white, needle-shaped crystals, showing a dark violet reaction with concentrated sulphuric acid.

Similarly, a method of preparing artificial vanilline is given by Dr. Haarmann, of Holzminden. The raw product, according to Dr. Haarmann, from which vanilline is obtained is coniferine, a glucoside contained in the cambial juices of the Coniferæ. This substance is obtained in localities in which the wood is cut when in sap. The Coniferæ (red and white pine) are stripped of their bark, and the sap under the bark, together with a portion of the bast, scraped away with broken glass or knives and collected in vessels. As the sap easily ferments, and in that case completely decomposes, it is filtered away from the bast as soon as possible and boiled, then separated from the coagulated glair, evaporated to a fifth part of its original volume, and left to crystallize. After a little time the crystals that have formed are removed from the mother lye by pressure. One hundred liters of the sap, obtained with so much difficulty, yield ½ to 1 kilogramme of coniferine. In the subsequent process the coniferine is treated with oxidizing substances (sulphuric acid and potassium bichromate) and the vanilline either distilled with steam or eliminated from the solution by means of ether. To remove the vanillic acid evolved with it, the product is subjected to a

further cleansing process with a solution of sodium bisulphide and recrystallized. After this treatment the vanilline appears as a nearly white, crystalline powder with a melting point of 80 to 81 deg. C. Twenty grammes of this substance are equivalent to 1 kilogramme of best vanilla, the latter containing on the average two per cent of it.

Wood vinegar may also be made from sawdust whenever the preparation of this substance from alcohol is not remunerative. One hundred kilogrammes of sawdust will yield from 45 to 54 liters of a liquid containing four per cent of acetic acid. From 6 to 8 liters of tar are formed at the same time.

Interesting from a technical point of view is the employment of sawdust as an adjunct to mortar to prevent cracks in plastering. The sawdust is thoroughly dried and sifted in an ordinary screen to remove any coarse pieces, only the small wooly flakes remaining for use. The mortar is mixed with 1 part cement, 2 parts lime, 2 parts sawdust, and 3 parts sharp sand. The sawdust is first mixed dry with the cement and sand and then added to the lime.

Dry distillation of sawdust is commenced at a temperature of 100 to 130 deg. C. At first only water distills over, the quantity depending, of course, on the more or less damp condition of the sawdust. According as the latter has been kept in the open air or in a confined space, it will contain a greater or less amount of moisture, which will greatly affect not only the quantity of water escaping during distillation, but also, being closely connected with it, the consumption of fuel. It is therefore advisable to subject the sawdust to a preliminary drying whenever possible, and not to put it into the distilling apparatus before it is thoroughly dry. The temperature is raised from 145 to 500 deg. C., and the products of distillation are water, wood vinegar, wood spirit, and tar. Acetic products then compose the bulk of the distillates when the temperature is quickly raised; they must be rapidly removed if they are not to be exposed to further decomposition.

Wood waste, that is, flaw pieces after the regular boards are cut, can also be used in making casks, and the waste from sawmills in the manufacture of slabs for parqueted floors.

Manufacture of Stoppers from Wood Shavings.—Franz Koeller, of Neulengbach on the Westbahn, Lower Austria, has patented a method for making stoppers out of wood shavings. The shavings are wrapped or rolled round a small circular wooden stick, and both ends of the shavings fastened to the stick and also to the periphery of the plug by means of some binding material, such as resinous or rubber cement. The length of the stick is equal to the width of the shaving, and the stick offers a firm support to the corkscrew for removing the stopper from the neck of the bottle or jar.

In conclusion we may refer to the manufacture of briquettes out of sawdust. Molasses has been recommended as an excellent binding material for sawdust in the manufacture of briquettes. The sawdust is moistened and well mixed with diluted molasses, pressed in cylindrical, brick, or other molds, and dried.

Rosin and tar also make good binding agents. A profitable result from the manufacture of briquettes depends, of course, upon local conditions, especially on a regular supply of this waste.

HORN SHAVINGS.

Utilization of Turnings and Filings.—A strongly-saturated solution of potash and slaked lime is poured over the shavings. After remaining for a considerable time in this solution, the horny substance gets cleaned and passes over into a gelatinous mass. After the application of moderate heat the mass can be poured into molds and pressed; in this way the moisture will be removed, and the mass will become firm. Further heating and pressing will give a completed form to the molded mass, which can then be worked into various articles, such as mouthpieces for pipes and cigars, handles for walking sticks, buttons, etc.

Horn waste can also be utilized by the following process: The turnings, raspings, or filings are pressed into a thick mass in a metal cylindrical mold by means of a metal stamper, heat being applied all the time; the mass is then rasped into a fine powder, which is again compressed in the same manner, the process being repeated till the mass attains a sufficient degree of compactness and strength. It is then again rasped, and well sifted to remove all the coarser particles. As a rule, horn shavings are worked together with tortoise-shell waste; when made from this combination, articles are less brittle than when made of tortoise-shell alone. The articles are made from the fine powder by the following process: The powder is placed in layers between brass plates, and several such layers put under the press and dipped into boiling water; this will make the mass firm and coherent. The plates are then worked up as required, or the articles may be made directly from the mass, provided the requisite molds are at hand.

We will now describe a method of treating horn shavings by which handles for walking sticks and umbrellas and a number of other articles can be made from the mass by pouring the latter into molds.

One thousand parts by weight of unslaked lime, 500 parts of potash, 40 parts of tartar, and 30 parts of salt are dissolved together in water, and one-third of the quantity of water used evaporated. The rasped horn or turnings are then thrown in, and the whole again boiled till the mass is thick enough to be poured into the mold. The mold, whether it is made of metal, wood, or burnt clay, must be well oiled. If the rasped horn is to be colored, the desired color should be stirred up in the liquid mass before the latter is poured into the mold.

The horn shavings may also be boiled in a strong lye of lime and potash till the mixture is thick enough to be poured into the mold, the coloring matter being added before molding.

To make a coherent horn substance out of horn shavings, Pathe places the latter in a liquid consisting of a cold-saturated solution of boracic acid in water and a cold-saturated solution of arsenious acid in dilute hydrochloric acid of 1.0 sp. gr., twice as much boracic as arsenious acid being used. The horn substance rising to the top of the liquid is placed in a vessel which is immersed for an hour in a water bath of 60 deg. C., and the mass is then subjected to vigorous pressure by a stamper in closed iron molds heated to 120 deg. C. till all moisture has been removed. On cooling, the pressed mass appears in the form of compact horn plates, which can be worked up like natural horn and are characterized by remarkable pliability and elasticity.—Translated from "Verwerthung, etc., von Abfallstoffen."

THE EFFECT OF AIR WAVES ON ASTRONOMICAL OBSERVATIONS.*

By G. MILLOCHAU, of the Observatory of Meudon.

THE atmosphere of the earth is a serious cause of disturbance in astronomical observations. Aside from the effects of its selective absorption and of the clouds and fogs which it holds in suspension, the atmosphere in its most transparent condition causes phenomena of refraction which interfere with telescopic work. The most annoying of these phenomena is that which produces unsteadiness of the telescopic image.

When a large telescope is directed to a star in one of those rare instants when the atmosphere is perfectly calm, an observer looking through the eyepiece sees a well-defined, luminous point surrounded by a number of concentric circular diffraction rings of less brilliancy. Usually, however, the appearance of the field of view is very different from this, the bright point being replaced by a spot of appreciable size and irregular form which is in almost incessant motion.

Between the most unfavorable case, in which the star presents the appearance of a nebula, and the most favorable, in which the image is perfectly sharp, there are many intermediate conditions which permit observations to be made but which the conscientious observer is compelled to note and study with care in order to avoid the danger of drawing erroneous inferences from his observations.

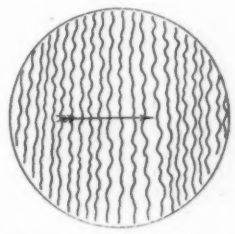


FIG. 1.—APPEARANCE OF THE OCULAR CIRCLE OF THE LARGE OBJECTIVE OF THE MEUDON OBSERVATORY.

Diameter, 33 inches; focal length, 52½ feet. Nov. 18, 1906. The bands moved in the direction indicated by the arrow.

If, when the telescope has been directed to a bright star, the eyepiece is removed and the eye placed at the focus of the objective, the latter appears brightly illuminated by the light of the star, forming the so-called ocular circle, on which are projected the shadows of all opaque objects that intervene in the path of the rays, such as spots and dew on the objective.

In atmospheric conditions which make the telescopic image indistinct this ocular circle is seen to be traversed by moving, undulating bands, alternately light and dark, as illustrated in Fig. 1.

The influence of atmospheric vibrations on telescopic images may be shown by the following simple experiment. A lamp is shaded by a thin sheet of copper in which a very small hole has been bored and the hole is viewed through an opera glass from a distance sufficiently great to permit accurate focusing. Now, if a lighted spirit lamp or other source of heat is placed between the luminous point and the opera glass, below the line which joins them, the image becomes unsteady and deformed like the telescopic image of a star in certain conditions of the atmosphere.

Another experiment, equally simple, reproduces the phenomenon still more exactly. A sheet of tin foil having a very small perforation is placed at the bottom of a deep glass jar, which is filled with water (Fig. 2). The hole in the tin foil is illuminated by means of a mirror below the jar, and another mirror, above, reflects to a telescope the luminous pencil that has traversed the hole and the liquid. If ripples are formed by blowing upon the water or by other means the image of the bright point in the telescope becomes agitated like that of a star seen in certain atmospheric conditions and corresponding light and dark bands appear in the ocular circle when the eye-piece is removed.

The resemblance is sufficiently exact to suggest the idea that the disturbance of the telescopic image of a star is due to atmospheric waves.

* From La Science au XXme Siècle.

Over any given point of the earth's surface there are, nearly always, two atmospheric currents flowing in opposite directions. The upper and lower current differ in temperature and hygrometric condition. If their surface of separation is a uniform plane the telescopic image is not disturbed, but if this surface is undulating the luminous pencil is irregularly refracted and the image is agitated and made indistinct.

My observations of the effects of these air waves has led me to divide them into three groups:

1. Very small waves with a very rapid movement of progression (originating in the upper strata of the atmosphere). In this case the image of a luminous point is a very small spot of irregular shape in incessant motion. If a planet is under observation its limb (or edge) appears sharp, but the large details are tremulous and confused and the fine details invisible.

2. The waves are larger than in the preceding case, but are smaller than the objective or of irregular form, and have a rapid movement of progression. In this case stars resemble large nebulæ and no details of planets can be made out except the larger markings, which are indistinct and greatly distorted.

3. The waves are much larger than the objective and move slowly. In this case the images are sharp at intervals, the duration of sharpness increasing with the size and slowness of the waves. It is only in this condition of the atmosphere that planetary and most other astronomical observations can be satisfactorily made.

It can easily be shown that two distinct effects are produced. The image of a star is subjected to small lateral displacements and the focal plane of the telescope (the plane of maximum sharpness of the image) oscillates between two extreme positions. The distance between these limits can be determined by three different methods:

1, by moving the eyepiece in and out until the image ceases to be sharp even for an instant; 2, by a comparative study of photographs of stars on plates exposed at slightly different distances from the objective; 3, by comparing the results obtained by focusing stars on the slit of a spectroscope.

Experiments of this sort made with the large telescope of the Meudon observatory, which has a focal length of 16 meters (52 feet 5 inches) have shown that the distance between the limiting positions of sharpness is about 3 millimeters (⅛ inch) and that the period of oscillation of the focal plane is about one second, increasing with the magnitude of the air waves.

It appears, therefore, that the atmospheric waves have the general form of ocean waves, so that their effect is that of a series of gaseous lenses, alternately

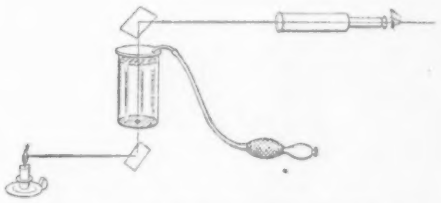


FIG. 2.—APPARATUS FOR REPRODUCING THE EFFECTS OF ATMOSPHERIC WAVES BY MEANS OF WATER WAVES.

convex and concave, moving in front of the objective, the irregular surfaces which connect the convexities with the concavities causing the indistinctness of the image between moments of sharpness.

It follows that ocular observation gives better results than photography unless the exposure is very short, as the eye can accommodate itself to changes which would blur the photograph. During and before cyclones the images are of the second of the above-mentioned types, showing that the atmospheric waves are of irregular form. The image may also be affected by eddies in the lower air current, due to elevations and depressions of the ground. Hence, the site of a large telescope should be selected with great care. A peak much higher than neighboring summits is a favorable location, but the center of an elevated plateau, far removed from mountains, is still better.

A problem which is agitating the minds of many far-seeing investigators, is the question of the supplies of artificial plant-food, aside from that involved in the question of nitrogen. It has been clearly demonstrated that so far as the mineral elements are concerned, there is sufficient in the soils of this country to supply the needs of maximum crops for centuries, but that statement must be modified, so as to read "sufficient to supply the needs of general crops, cereals, and grasses, or any other crop which in its cultivation is allowed to develop under natural conditions," but it does not apply to that class of crops, the need of which is increasing rapidly, that can not be grown to perfection in such quantities as to meet the demands of a modern civilization, without the stimulating effect of immediately available plant-food. We refer to the large number of vegetable crops, fruits, berries, etc., which must be produced under semi-artificial conditions, in order that they may possess those characteristics of quality, and be provided at such times as the present demands require. There will, therefore, be a constantly increasing demand for plant-food, which can not be supplied by natural means, including the use of homemade manures.

ENGINEERING NOTES.

No evolution and improvement has taken place in the boiler house commensurate with that of the electrical equipment of large power plants; probably in every case the same boilers are at work, doing practically the same duty and at approximately the same efficiency as they gave when first put to work. The consequence is that they are unable to supply sufficient steam for the larger generating units now installed in the engine room—to supply this extra steam more boilers have had to be installed; thus the boiler house equipment becomes longer than the engine room, and complicated and wasteful arrangements of steam pipes ensue which are expensive and undesirable.

Loicq de Lobel's scheme for the construction of an intercontinental railway under Bering Strait has been put into corporate form by the organization in New Jersey of the Trans-Alaska-Siberian Railway Company with a capital of $6,000,000. The incorporators besides de Lobel, who is a Parisian, are J. A. L. Waddell, of Kansas City, Mo.; John J. Healy, of Seattle; William H. Black, of New York; and John R. Turner, of New Jersey. M. de Lobel has made several visits to this country seeking financial aid. The Czar some months ago appointed a commission to consider the proposals advanced by M. de Lobel. The line as proposed has a total length of 3,750 miles, exclusive of over 2,000 miles of branches. It is planned to start from Kousk, a station on the present Trans-Siberian Railway. After passing through a tunnel under Bering Strait, the plan calls for a line traversing Alaska, passing through Grently Harbor and Council City.

In the coal which is usually supplied for generating producer-gas there are invariably traces of sulphur, and the result is that sulphureted hydrogen is made and gives to the gas an objectionable odor. In some of the generators methods are used whereby the sulphureted hydrogen is removed from the producer-gas. As sulphureted hydrogen attacks copper, it is therefore advisable that in any case as little of this metal as possible should be used. Ammonia gas is also obtained in generators, and this has a corrosive effect on copper and its alloys; but fortunately it is very soluble, and consequently is absorbed in the waters in the "scrubber" before the producer-gas reaches the engine. It has been found that generators which utilize certain fuel cannot work on the suction principle, because the nature of the fuel will not permit the gas to pass easily through. The resistance offered by the fuel is not only considerable but also very variable, which intensifies the difficulties. Consequently, generators have been invented and constructed which operate on the pressure principle, and a blast of air or perhaps a jet of steam is used. Such generators, however, are not recommended for sizes under about fifty horse-power, because it has been proved that the cost of such apparatus is more than is compensated by any advantages gained in sizes below that mentioned. Foremost with the development of producer-gas and gas engines must be connected the name of that pioneer Thwaite, and it should be noticed that in his producer, as indeed is the case with the Riché producer as well as the Duff, the products of distillation are decomposed by passing them over layers of incandescent fuel.

In 1886 the rail mill of the Edgar Thomson Works had been doing great work, but it was being pressed in output by other mills, and Mr. Andrew Carnegie then, as on many other occasions, displayed his acute business acumen, and directed Capt. William R. Jones, manager of the works, to prepare plans for the very best rail mill he knew how to design. Capt. Jones tells that some time afterward Mr. Carnegie asked him how he was progressing with his plans, and, on his reporting, asked how much the mill would cost. The Captain replied that he could not then tell. Mr. Carnegie said: "Well, but we must place some limit on its cost." Jones answered: "You told me to design the very best mill in my power; now if I am to be limited by the cost sheet in so doing I must give up the job." Mr. Carnegie then asked, "But if we build such a mill how much will you promise to increase its production over the present one, and how much per ton will you save?" Jones answered, "I will promise to double the output, and save 50 cents per ton." "All right," was the answer, "go ahead, and do your best." The new mill started in 1888, and all promises for it have been much more than fulfilled. Its record production of rails for a month is 61,033 gross tons. There are three sets of rolls in this mill, which are placed tandem. It has been strengthened since Capt. Jones's death, but is practically his mill. The converting works, which were originally designed by A. L. Holley, afterward altered and added to by Jones, and again by C. M. Schwab, have made 102,500 gross tons of ingots in a month, all of which were bloomed in one blooming mill. After the starting of the new mill, the original Edgar Thomson rail mill remained idle for several years. It was then remodeled, and used for the production of rails, mostly under 60 pounds per yard, and has been in practically constant operation ever since. Within the last year another rail mill has been added to the plant, and one which is quite a departure in the business. It consists of two sets of 18-inch rolls, placed tandem, and equipped with automatic tables, the power for both rolls and tables being electric. It is intended to use this mill for the reduction of second quality rails of standard sections, made in the other mills, to lighter ones, but as yet it has been principally used for rolling small-sectioned rails from billets.

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